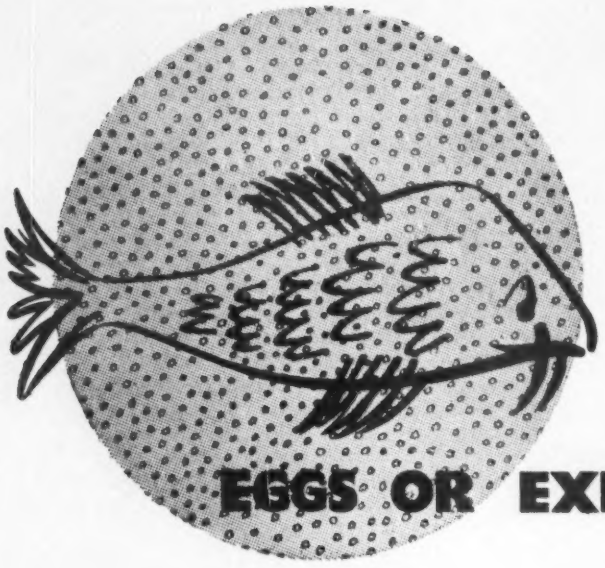
DISCOVERY

JULY 1958 2/6



EGGS OR EXPOSURES

A famous writer once said that a photographer making exposures reminded him of a codfish laying million of eggs in the hope that one or two would survive.

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DISCOVERY

VOLUME XIX JULY 1958 NUMBER 7

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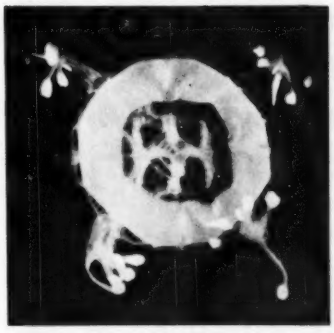
OUR COVER PICTURE



Chironex fleckeri, photographed from below. Specimen with tentacles removed (see pp. 282–5)

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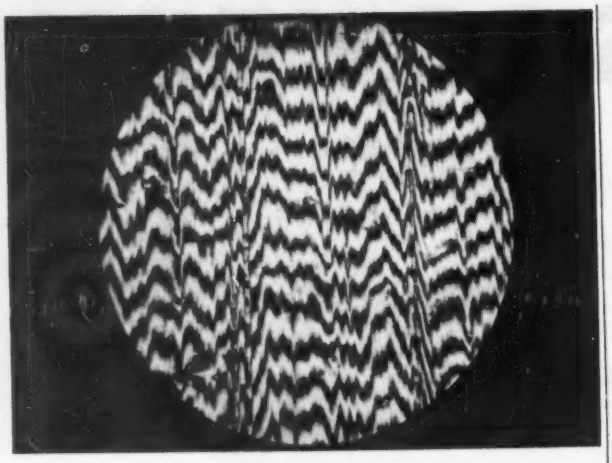

Ups and downs . . .

on a surface that should be smooth are a constant source of trouble to the engineer. How is he to remove things that he may not be able to see? The answer is to make them visible with an interferometer, which will show them plainly, even though they amount to no more than a fraction of the wavelength of light. We, of course, make all sorts of interferometers and interferometric apparatus—some for measuring lengths, some for increasing the resolving power of spectroscopic instruments, some for testing prisms and lenses, and some for examining surfaces and measuring their irregularities.

¶ The photograph shows a ground, and supposedly flat, steel surface as seen by the Hilger & Watts surface micro-interferometer. If the surface were truly flat, the interference fringes would be straight and parallel.

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THE PROGRESS OF SCIENCE

TIME IS NOT ON BRITAIN'S SIDE

What is the mood in Britain today? Is it one of caution and complacency, or is it based on a readiness to confront and surmount the obstacles before us? DISCOVERY has no doubt what our mood should be. To scientists, the danger of marking time (the current affliction of our economy) is not merely one of national opportunity lost, it is that a general mood of apprehension and talk of slump could distract attention from our long-term problems. Of one fact we should never lose sight. When the British economy does expand, it will be subject to unparalleled strains, and before it will be ranged a battery of shortages, human and material, each in itself sufficient to paralyse our progress. What are these shortages, and how do they particularly concern scientists?

First, inadequate investment. In a fully employed economy, progress depends on greater output per man, that is, higher productivity. This, in turn, can only be achieved if technical progress is maintained, and more machinery is available to back up each worker. In no other developed economy has it been as difficult to provide resources for investment as in Britain. We can leave out of the picture Soviet Russia, where methods differ so greatly from our own, and which, not counting defence, devotes about a third of the national income to investment. We cite Western Germany, where 32% of the national income is invested, and the United States, where 22% is invested, compared with only 20% in Britain. This, according to a recent estimate, is by no means the full story: the American citizen starts off from a higher base-line, and sets aside for investment over half as much again as the German citizen, and two and a half times as much as his British counterpart. But the average Briton has a far higher living-standard than his German counterpart, and claims a living-standard two-thirds as high as that which the American worker enjoys. How long can this continue?

These comparisons have a direct bearing on our serious dollar problem. The dollar gap is not merely a measure of our inability to ride out a sudden psychological crisis of confidence; it reflects our long-term inability to afford the many American imports to which our way of life and aspirations are none the less geared. Thus, the sterling area's reserves, which before the war, could pay for nearly nine months of the area's imports from the rest of the world, can today barely finance three months' imports. Low dollar reserves also reflect our potential shortage of raw materials, not merely because we must buy from the United States, but because we may have one day to buy in competition with her. In the last half-century, American production of raw materials, including synthetics, rose nearly three times, but thanks to her industrial expansion, her consumption rose three and two-thirds times. Conversely, the rest of the world's raw-material production went up nearly three and a half times, but its consumption rose under three times. As well as being a big importer of raw materials for industry, the United States may in time become a big net importer of food as well. All this may be beneficial for primary producers, but it will hit manufacturing Britain hard. There is already widespread recognition of the contribution which science, through the development of atomic energy, can make to meet the ever-increasing deficit in our fuel supplies—estimated at 70 million tons of coal annually by 1980. Perhaps even more dramatic, if Britain is to sustain her industry, is the role science must also play in the development of synthetic materials.

But material resources are valueless without human resources. If technical advance is to be fostered, we must have not only more scientists and science teachers to train them, but generally more skilled personnel at all levels. Already we are lagging behind our competitors in the supply of science and engineering graduates. Meanwhile, it has been officially estimated that to maintain a modest 4% annual growth in industrial output will, over ten years, require an increase of 60% in the total number of scientists and engineers employed—indeed, by 1970, we shall have had to double our output of these graduates. This extra manpower will not appear for the asking. Children will have to be persuaded to stay on at school and proceed to university; a substantial switch from arts to science faculties will be imperative; able children who are now lost to higher education via the secondary modern schools will have to be retrieved. Finally, where are the teachers? Even according to our complacent official estimates, the teaching force, if it is to meet its commitments, must rise some six or seven thousand per year, at least a thousand of whom should be graduate science teachers for the grammar schools. Everyone, however, recognises that if educational standards are to be substantially improved, these estimates are absurdly conservative. Science and schoolteaching are not unique in facing a shortage of trained manpower; this problem will extend throughout the labour force, as the demands of a changing industry grow more exacting, and as the burden of our relatively ageing population grows.

Our last example is all too readily overlooked—the fact that ours is a small island where space is limited, where room to reconstruct cities and rehouse our population is lacking, where urban development threatens to sterilise scarce agricultural land, where our roads are shockingly congested, yet where our population of cars is likely to double in the next ten years.

How can such bottlenecks be overcome? Certainly not by waiting for something to turn up. We do not advocate solutions to this problem or that; our duty is to pinpoint two issues—first, the part that science should play in solving our problems, and second—more important still—the significance of the scientific method. Problems can only be overcome after systematic analysis and thought. The methods of operational research must be invoked not merely to seek a solution to a particular problem, but to help towards a constant re-appraisal of priorities and to speed our evolving society in its battle against time.

ROYAL SOCIETY CONVERSAZIONE

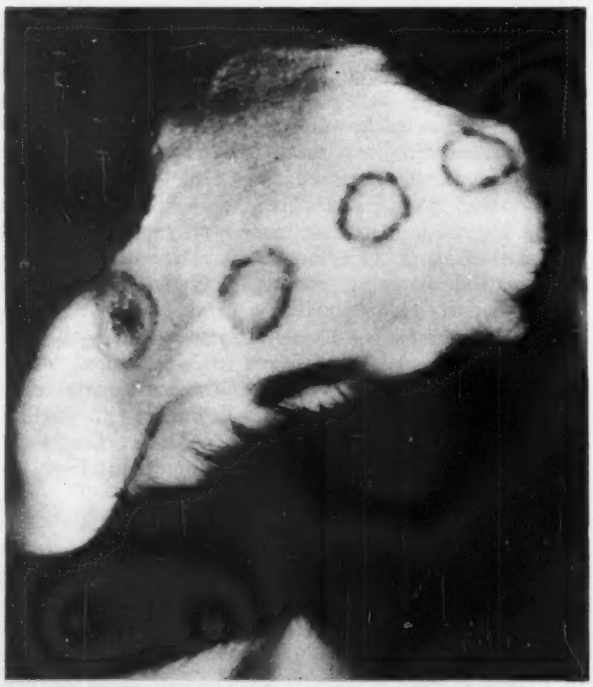
At its annual reception to Fellows of the Society and other distinguished scientists, the Society presented this year an unusually interesting series of exhibits. Perhaps even more, it was a pleasure to note that the presentation of each item was carried out in a far more professional manner, that the legends were far more readable and uniform than in the past, and that clarity of exposition and space in which to move, were primary considerations. The excellent exhibition held a year ago on the occasion of the inauguration of the IGY has certainly left its welcome mark. A total of twenty-seven items were presented, and the film "Transonic Flight" was projected. Only a few of these items can here be described and it is still hoped that one day the Royal Society, perhaps in collaboration with the British Association or the Science Museum or some other body, will find the means to bring its visual research report to a wider audience.

Interferon, an Inhibitor of Virus Growth, by Dr D. C. Burke and Dr A. Isaacs. National Institute for Medical Research, Mill Hill.

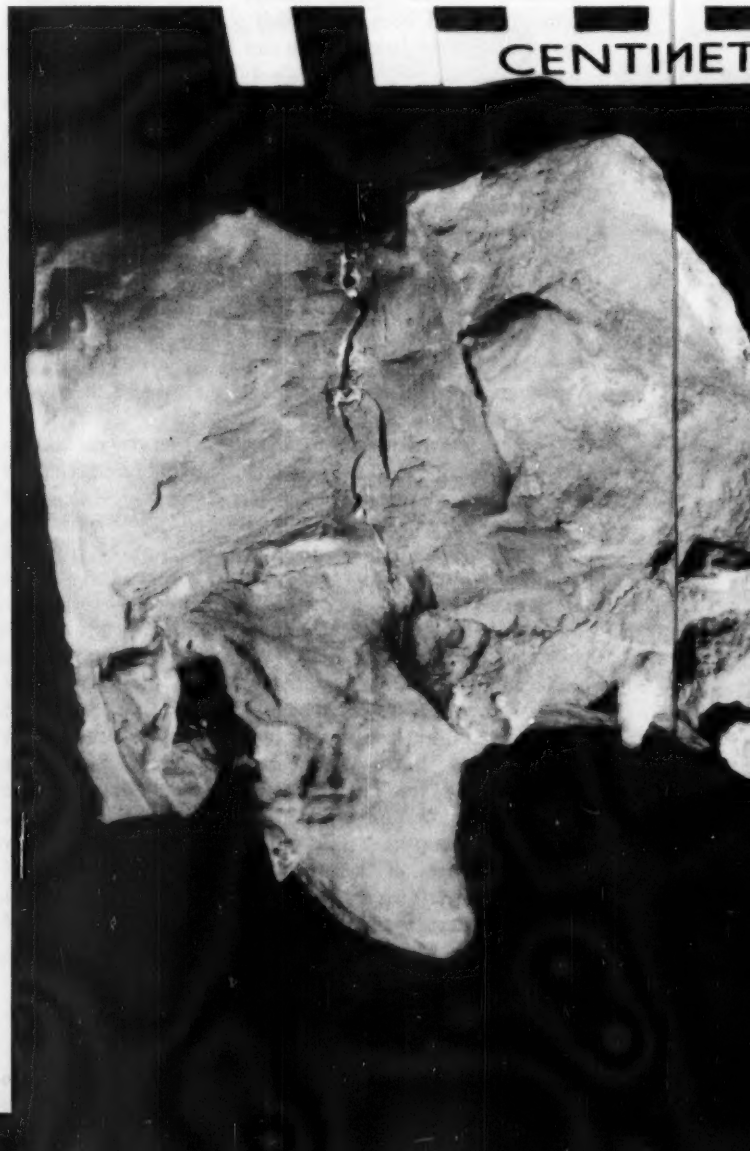
So far no antibiotics active against viruses have been discovered. To a large extent this is because viruses are extremely small parasites which are obliged to live inside cells, and it has not been possible to find a substance which would stop viruses from growing without at the same time harming the host cells. Interferon is the name which has been given to a new substance which prevents the growth of a number of viruses without apparently causing any gross damage to the cells. Interferon does not kill the viruses, but stops them from multiplying. This was found during the study of virus interference reactions—a phenomenon in which one virus interferes with the growth of a second unrelated virus.

The demonstration showed different aspects of the study of interferon. Interferon can be readily produced on a laboratory scale without requiring any complicated apparatus; the interfering activity of the material produced is then measured by its ability to prevent the growth of influenza and related viruses in pieces of chick tissue in test tubes; when these interferon preparations are concentrated about ten times they reduce greatly the growth of viruses such as vaccinia and cowpox (close relatives of smallpox virus) in fertile hens' eggs, and prevent completely the "vaccination" nodules produced by vaccinia and fibroma viruses in the rabbit skin.

Interferon is of theoretical interest as a tool for studying how viruses multiply, and its practical interest lies in the facts that it is easily produced, that it is active against a wide range of viruses, that it is active not only in "test tube" experiments but also in animals, and that it does not seem to cause any obvious damage to the animals. However, a great deal of research lies ahead before it will be clear whether it has any practical value for preventing or treating virus diseases of man.



Skin of a rabbit inoculated in four sites with the same dose of vaccinia virus. In the three left-hand sites different doses of interferon were given before the vaccinia. The right-hand site is a control and was pre-inoculated with buffered salt solution. The experiment shows a protective effect of interferon on the growth of vaccinia virus.

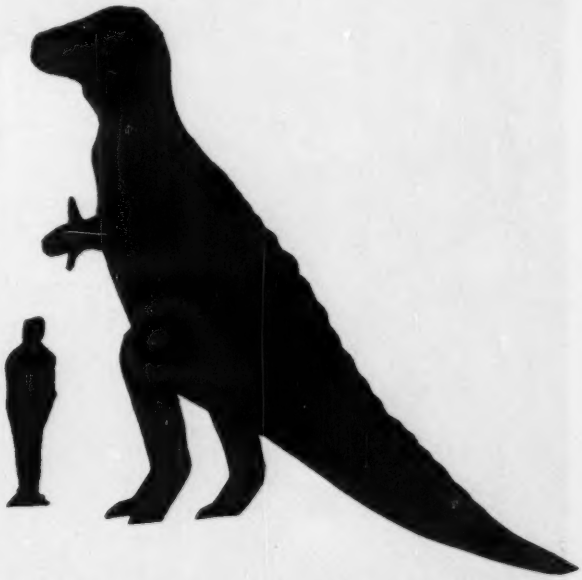


Dinosaur Brains, by Dr W. E. Swinton, Department of Palaeontology, British Museum (Natural History).

An obvious difficulty in trying to re-create the living abilities of the animals of the past is to determine the criteria that can be used with confidence. With the dinosaurs this problem is partly solved by studying the shape and size of the brain. The actual nervous tissue has, of course, always been lost, but the space in the skull remains and casts can be made of it in plaster or in plastics.

Reconstruction illustrations of dinosaurs frequently suggest active modes of life in several habitats. One of our ways of amplifying or restricting these imaginary pictures is by examining the development of the dinosaur brain. No fossil brain of this kind has been found, but the cavity in which the brain was originally contained can often be investigated and casts of it can be made in plaster or in the new plastic materials. This does not always, of course, produce an exact copy of the brain, for we know from studies of other reptiles that the amount of space occupied by the brain in the endocranial cavity varies considerably. The brain of the crocodile, for example, occupies only half the space and is surrounded by liquid. The dinosaur brain was probably surrounded by an amount of connective tissue and some of the cavities, such as the *sella turcica*, housed not only the pituitary gland but also the internal carotid arteries and parts of the optic muscles. The exhibit showed a number of casts taken from dinosaurs of various kinds and attempts to estimate the relative values of some of the senses, as disclosed by the brain.

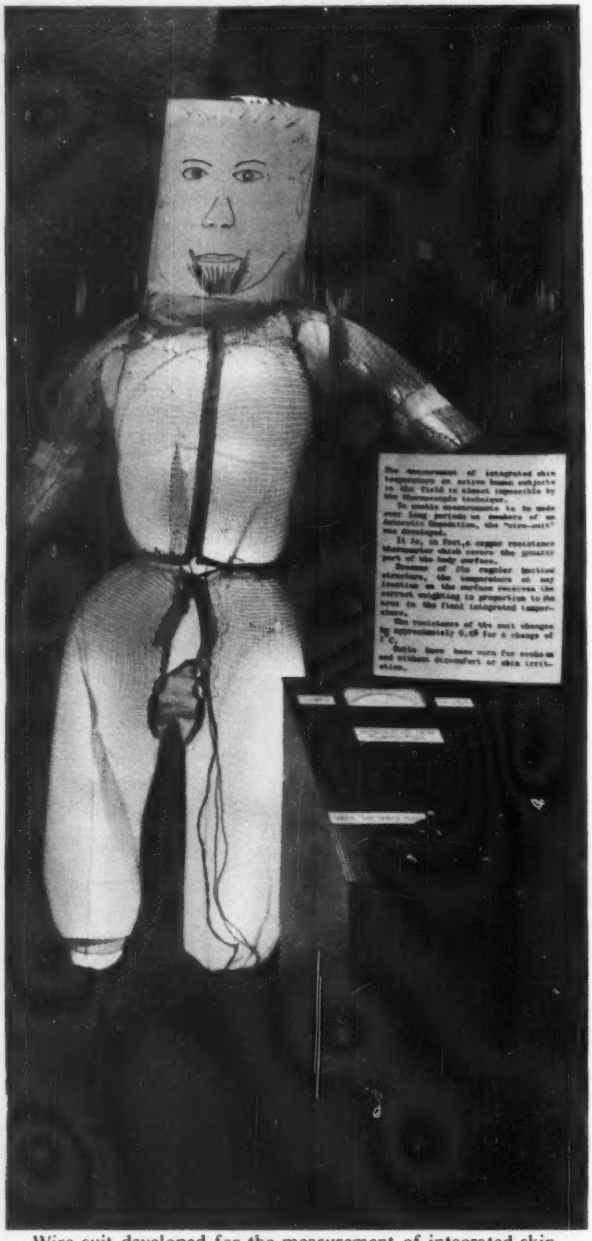
The results are remarkable. It is seen that some of the largest dinosaurs, 80 ft. long and weighing nearly 40 tons are controlled by brains no larger than that of a kitten but not so highly organised. Another large and heavy dinosaur, armoured against its enemies, and weighing 7 tons or more, had a brain of only 2½ oz. Studies of this kind show that dinosaurs were slow and cumbrous in reaction as well as in bodily movement and thus were incapable of the actions imputed to them in many reconstruction pictures.



(*Above*) Silhouette of *Iguanodon* as compared with that of a man. This dinosaur carried its head in this pose about 14 ft. from the ground. Its total weight must have been about 7 tons, the large body being served by a brain seldom more than 8 oz.

(*Left*) Photograph of an entirely new plastic cast of the endocranial cavity of the large bipedal herbivorous dinosaur, *Iguanodon*. The skull concerned came from the Isle of Wight. The cast shows the relative development of regions of the brain as seen from the right side. The pendant structure is the mass containing the pituitary gland and internal carotid arteries.

The brain of *Iguanodon* appears to signify fairly well-developed senses of smell, sight, and hearing, but the level of general intelligence was low.



Wire suit developed for the measurement of integrated skin temperature on active human subjects, intended for use at 12 volts.

A Knitted Wire Fabric for Measuring Mean Skin Temperature or for Body Heating, by Mr H. S. Wolff, Bioengineering Laboratory, Division of Human Physiology, National Institute for Medical Research.

By using very flexible insulated wire instead of thread it has been possible to knit complete garments, such as pants and vests, which are electrically continuous. Such a garment can be employed for measuring mean skin temperature by using it as a resistance thermometer. With careful knitting the number of stitches per unit area, and hence the length of wire per unit area, will be constant so that good integration is obtained.

The method was developed to enable continuous integrated skin temperature measurements to be made on working human subjects on an Antarctic expedition. In such a situation the conventional method of attaching a number of thermocouples to selected sites and weighting the individual measurements arithmetically to obtain mean temperature would be very difficult to apply.

The wire which has been used is 0·039 in. in diameter and contains sixty strands of 0·0016 in. silver-plated copper wire. It is insulated with a coating of polyvinylchloride containing a non-migratory plasticiser. It does not give rise to any skin reaction even after prolonged wearing. The fabric is very flexible and does not limit movement or produce discomfort.

It is likely that the fabric will find its biggest application in the construction of heated clothing. One advantage over conventional heated clothing will be that the fabric is very flexible and will not break under constant flexing. Another advantage is that the area of the body which can be covered by the "element" is much larger so that hot-spots can be avoided even if the power input to the garment is much increased. The efficiency of the heated garments is high because the heat is liberated next to the skin.

A temperature-measuring suit and a pair of heated gloves were demonstrated.

Measuring the Water-Permeability of an Insect: Apparatus Incorporating a Novel Thermostat, by Dr J. W. L. Beament and Dr K. E. Machin, Department of Zoology, University of Cambridge.

The skin or cuticle of insects is one of the important barriers to the entry of insecticides; it also prevents such small animals from "drying up" for it is extremely waterproof. Simple measurements suggest that the minutely thin layer of wax on the cuticle surface cannot account for the small rates of water-loss unless the wax has some special and unknown property. The apparatus demonstrated was designed to measure accurately the amount of water lost by an insect in dry air at different temperatures, or by revealing the nature of the property giving the wax its great impermeability.

An insect was suspended in dry air from a delicate balance; as water evaporates from its skin, the specimen lost weight. But just as we are cooled if we perspire and the moisture evaporates, so also the skin of this insect is cooled as it loses water. A thermocouple against the insect's surface measures this cooling relative to the temperature of the air—which must therefore be controlled accurately.

The usual way of regulating temperature involves a control which switches a heater "on" and "off" at intervals; corresponding fluctuations about the desired temperature must therefore occur. In this apparatus, the heater is always partially on, and it is "turned up or down" by an electronic regulator until it is giving out just the amount of heat needed to keep the air *at* the required temperature.

Using this apparatus, experiments confirm that the insect skin is very waterproof, but that at a certain temperature it suddenly becomes much more permeable. Following this discovery, further research has indicated that the wax is in a special physical state which gives it a great resistance to water.

(By courtesy of the Science Museum)

Of the two early cine-cameras shown, the one on the right is Marey's *chambre chronophotographique*, the first real cine-camera. A photograph of Marey is in the foreground. The camera on the left, developed by Bull, dates from the first few years of the century and allowed him to analyse the flight of insects, a classical piece of research.

Early Cine-Cameras for the Analysis of Animal Movement, by A. Barclay, the Science Museum.

The work of Etienne Jules Marey in France between 1887 and 1900 may be regarded as the foundation of cinematography. Marey was a physiologist and medical research worker who utilised early photographic materials to analyse and record all kinds of animal and human movements, which up to that time had been imperfectly understood. His early work produced a succession of partially overlapping images on fixed plates, but as soon as sensitised photographic film appeared, first on paper and later on celluloid, Marey was quick to seize the opportunity of obtaining a longer series of pictures in rapid succession. In this way he was the first successfully to make cinematographic records of the flight of birds and the motions of horses, cats, and dogs, as well as of human beings.

Eadweard Muybridge in America had previously obtained very good studies of moving animals by employing a battery of cameras with ordinary photographic plates. Marey, however, used a single camera of his own invention, such as the example exhibited, which was designed in 1888 to take cine-pictures, and two years later, at a rate of up to 120 per second, no mean achievement at the time. Some of the results were shown, including two of the first records of the way in which a falling cat lands on its feet.

After Marey's death in 1904 the work was carried on by his pupils and collaborators, Pierre Noguès and Lucien Georges Bull. A film taken by the latter in Marey's last camera showed the American long-jump athlete, Kranslein, in action at the Paris Olympic Games of 1900. The ingenious spark drum camera invented by Bull in 1903 was also exhibited. It took stereoscopic pictures on cinefilm at rates up to 2000 per second and was the first machine successfully to analyse the wing-beats of insects. Some of the original results were exhibited.

The above work was carried out mainly at the Paris Physiological Station set up for Marey by the College of France, and later named the Institut Marey.

POUR TOUS LES TEMPS, POUR TOUS LES PEUPLES

One of the most powerful tools of the modern metrologist is provided by the well-known principle of the interference of light. Attention has recently been drawn to this, following an international recommendation that the metre be redefined as equal to 1 650 763·73 times the vacuum wavelength of the orange radiation of krypton-86. Such a possibility was foreshadowed as long ago as 1829 by J. Babinet during the development of the wave-theory of light. However, knowledge and techniques of measurement have only in recent years advanced far enough so that the metrologist now turns naturally to interferometry not only for pure length measurements but also in a large proportion of instances in which a problem can be resolved into one of length measurement of high absolute precision. Thus, for example, surface texture, or small local variations in form, can be assessed conveniently and accurately by measuring in wavelengths the separation between the surface concerned and another, flat, surface brought adjacent to it.

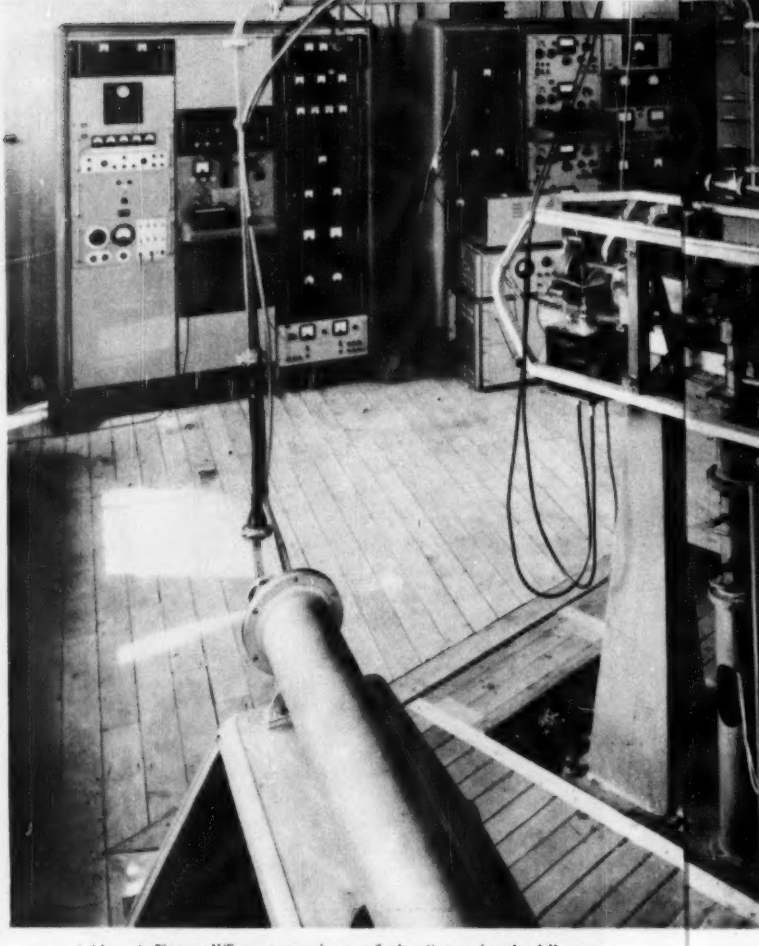
The principle of interferometry accordingly finds numerous applications in the work of the NPL Standards Division; many of them are of great industrial value. These were illustrated by a number of exhibits during the recently held Open Day showing the methods and techniques employed and the adaptability and accuracy of the principle.

In 1960 the platinum-iridium bar constituting the fundamental standard of length is likely to be superseded by the length of a wave of monochromatic light as the supreme arbiter for measurements of length. The century-old idea of adopting the light-wave as the ultimate standard of length has at long last reached the stage of practical realisation.

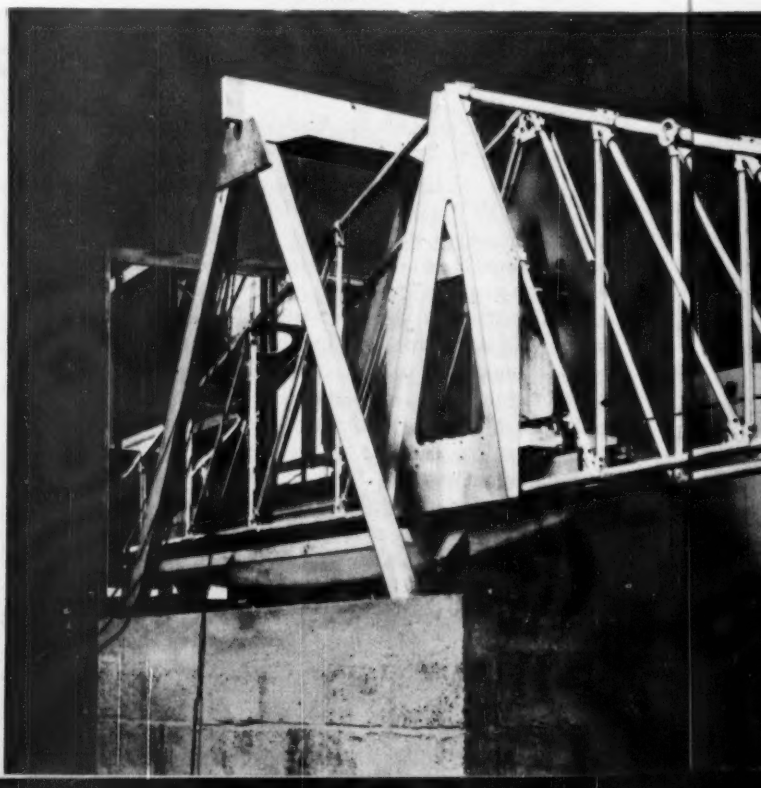
Measurements of length in terms of light-waves are made with instruments known as interferometers, designed to use the effects of wave interaction or interference. Some of the most precise measurements of length are made by such means. The metre and yard lengths have been evaluated by light-waves, and a notable example of the practical applications is the standardisation at the NPL of precision engineers' slip-gauges to one-millionth of an inch.

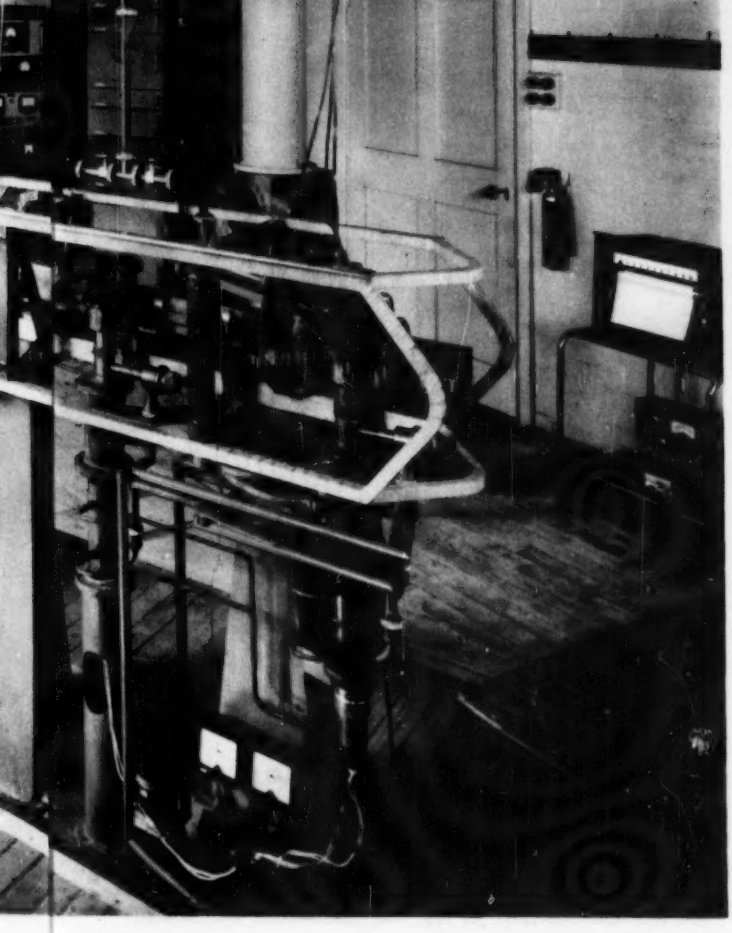
The proposed specification states that the metre equals 1 650 763·73 times the wavelength *in vacuo* of the orange radiation of the krypton atom of mass 86. The source of the radiation is a liquid-air-cooled discharge lamp containing krypton-86, an isotope which is isolated from natural krypton gas by a process of thermal diffusion. This source and radiation are the most suitable known to science and were selected as the result of meticulous spectroscopic researches co-operatively undertaken in the standards laboratories of many countries. The metre distance thus defined is indistinguishable in magnitude from that represented by the platinum-iridium bar but is estimated to be up to 100 times more precise. Apart from its advantages of permanence and reproducibility, the natural standard has qualities of accessibility and ubiquity not possessed by the material standard preserved in a vault under a suburb of Paris. The slogan *Pour tous les temps, pour tous les peuples*, devised by the creators of the metric system, will have better justification for the future when the representation of the metre becomes intangible.

The Standards Division of the National Physical

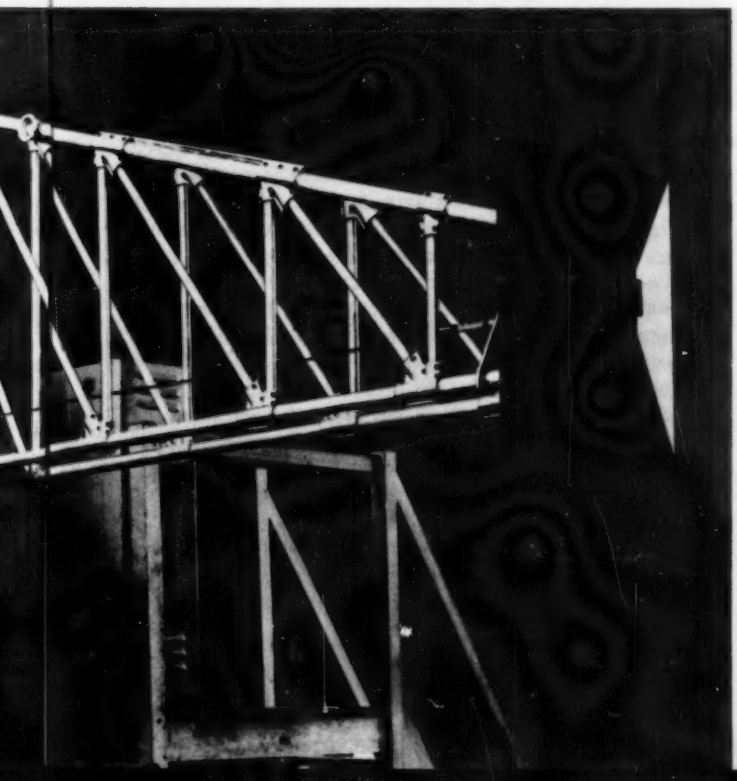


(*Above*) Four different versions of the "atomic clock" can be seen in this photograph. In the centre is the original NPL caesium resonator; in the left foreground is a transportable version, and immediately behind the original model, looking like a vertical stove-pipe, is the new long atomic clock. In the left background is the American Atomichron recently brought to this country for comparative measurements.





(*Below*) Microwave interferometer. The movable receiving carriage of the millimetre-wave interferometer which has been used for the precision determination of the free-space velocity of electromagnetic waves.



Laboratory also announced the result of a new determination of the velocity of "light" to a very high degree of accuracy. The result for the free-space velocity in a vacuum is 299 792·50 km./sec. (186 282·75 English miles per second) and the value is estimated to be correct to within three parts in ten million.

Strictly speaking, the measurement was not made with light waves, but with the very short radar waves (microwaves of 4-mm. length) emitted by a source operating at a frequency of no less than 72 000 Mc/s. Microwaves travel through gasless space at the same speed as light.

The determination was made by means of a device known as a microwave interferometer whereby it was possible to make an extremely accurate measurement of the wavelength of the radiation used. The product of this measured wavelength with the frequency of the microwave source gives the velocity of the waves in air. The frequency was obtained by comparison with a quartz crystal standard clock, and a special refractometer was incorporated in the equipment in order to obtain the slowing-down effect of the air. Although the whole equipment occupied 100 ft. of floor space, the actual distance over which the speed was determined was only 2 m. (6 ft. 6 in.).

The speed of light is one of the most important fundamental physical constants; it enters into both atomic and electromagnetic theory and the principle of the constancy of the velocity of light is a foundation-stone of relativity. An accurate knowledge of the constant is essential to radiolocation, but the practical applications requiring the very best value (e.g. at least 1 part in a million) lie in the field of geodetic surveying where two types of machine are available which in essence use the velocity of light for the measurement of long geodetic base-lines. Thus the new value—which is the outcome of several years' work and is believed to be the most accurate yet made by any method—is both timely and, in a sense, is a contribution to the International Geophysical Year.

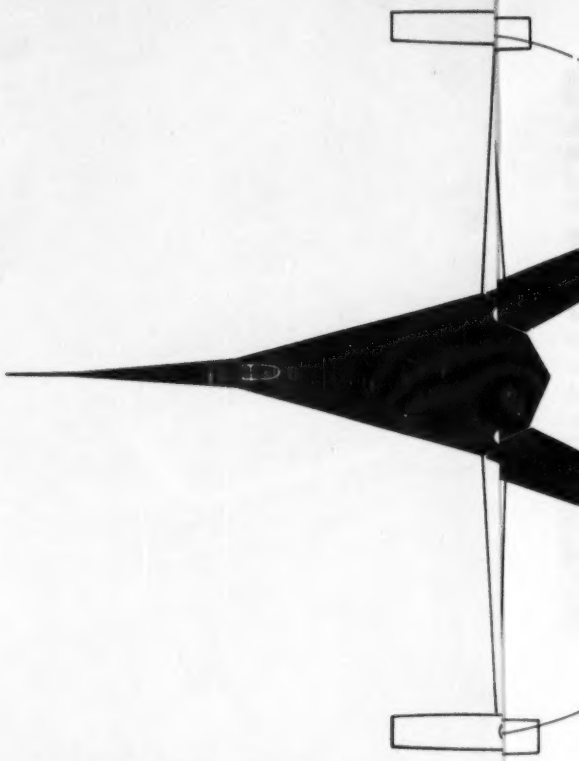
KEKULE AND COUPER

One centenary falling in 1958 concerns the very basis of building structural formulae for organic compounds, one so fundamental that it may be said that organic chemistry as a science was established 100 years ago. The two principles which were postulated pictured a carbon atom with a valency of four, that is, with four links by which four hydrogen or chlorine atoms could be attached; and a second point that carbon atoms could link together to form long chains. We accept these two points today as simple matter-of-fact fundamentals, so that it is almost forgotten how their introduction by August Kekulé and Archibald Scott Couper brought order out of chaos in seeking to assign the constitution of an increasing number of organic substances.

Organic chemistry texts give full credit to the better-known Kekulé, but the prior claim of Scott Couper was not fully established until R. Anschutz, Bonn professor of chemistry, and Prof. Crum Brown of Edinburgh had investigated the case, forms one of those stories of one man taking all the laurels. August Kekulé studied in Liebig's laboratory before spending a period with Dumas in Paris. Next he came to London as assistant to Stenhouse, where he had his first flash of inspiration while on top of a London bus—an incident he has himself well described.

though London Transport has not yet used the romantic touch! "One fine summer evening I was returning by the last omnibus, 'outside' as usual, through the deserted streets of the metropolis . . . when I fell into a reverie and lo! the atoms were gambolling before my eyes. . . . I saw how a larger atom could embrace three or even four of the smaller . . . and how the larger ones formed a chain. . . . The cry of the conductor: 'Clapham Road!' awakened me from my dreaming: but I spent a part of the night putting on paper at least sketches of these dream forms. This was the origin of my Theory of Molecular Structure." At Heidelberg, in a teaching post, Kekulé continued this theme, so that by 1858 he was able to publish in the *Annalen* his well-known principles explaining the constitution of aliphatic organic compounds, that is, of those with open chain formulae. Kekulé's name was so soon established that he was called to the Ghent chair of chemistry. Here it was that he added his ring structure for benzene and its derivatives, thus enabling the constitution of the other major class of organic compounds to be fixed—and all, once again, the result of his dreaming, of his sitting by the fireside and seeing "long rows" of gambolling atoms, "twisting in a snake-like motion and joining to form ring formations".

While Kekulé was elected to the chair at Bonn, becoming a baron and being celebrated throughout Europe, Scott Couper, who had developed the quadrivalency and chain-forming character of carbon atoms just previous to Kekulé, was to remain in obscurity until long after his death. Couper had published in the *Comptes Rendus* in 1857 some work on benzene and on salicylic acid, the latter subject attracting the interest of Prof. Anschutz when he read in an Edinburgh journal of philosophy a full account of Couper's study in place of the too brief abstract appearing in *Liebig's Annalen*. Anschutz was now attracted to Scott Couper's other work, reading the other published studies of 1858; and since he appreciated that Couper's basic principles for organic structures were clearer in concept than those of Kekulé, the search into Couper's story began. After periods studying philosophy with no chemistry at Glasgow and Edinburgh, this son of a mill-owner of Kirkintilloch spent a few years in Berlin for further study, a place where he became attracted to chemistry. Yet it was under Wurtz in Paris that Couper unfortunately went at the age of 25. It was unfortunate, for although Couper benefited from the research training in the research school, his original paper, "On a New Chemical Theory", which he handed to Wurtz for publishing in the proceedings of the Academy, was put aside. Wurtz was not himself a member of the Academy; and if he handed the paper to some member equally forgetful, the whole scheme was neglected until after Kekulé's paper had appeared in print. It was a brilliant theory for a man with only four years' training in chemistry, but was Couper's swan-song. He quarrelled with Wurtz, was expelled from the laboratory, found a laboratory assistant's job with Lyon Playfair, but ill health drove him to resign, with his last years spent partly in a mental home. For years Couper was thought to be a Frenchman; and although Kirkintilloch saw a commemoration in 1931 when eminent chemists celebrated the centenary of his birth, our chemistry texts of today still give Kekulé as sole creator of an essential principle.



THE VARIABLE-GEOMETRY AEROPLANE

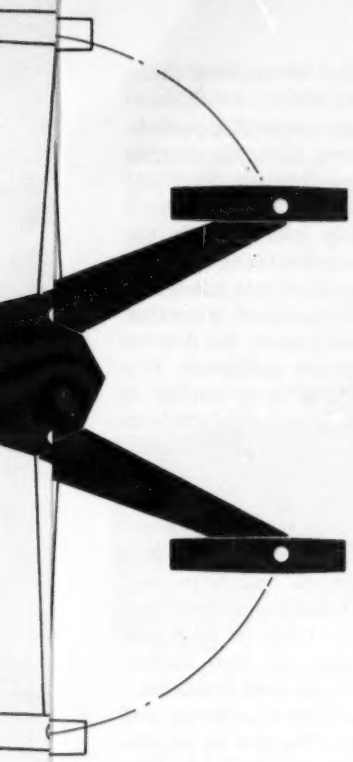
For a long time there has been nothing very remarkable in the announcement of new aeroplanes. But recently, while the number of aircraft being produced for civil and military purposes has fallen off with the advent of the "missile age" and the dawn of the "jet era" for commercial operations, the statement that a supersonic bomber was under development in Britain, caused something of a stir among all those interested in aviation.

The reason for the stir was twofold; firstly, the aircraft was of a revolutionary conception, and secondly it served to illustrate that there appeared to be plenty of future for the manned combat aeroplane after all. In recent months, service chiefs have become more disposed to saying that the guided weapon was still a fair way off, and that, contrary to earlier beliefs of the Government, there would be a need for manned military aeroplanes for the services.

The aeroplane itself was like something that had never been seen before—unless it was visualised in some of the more dramatic pulp fiction magazines. It was shown to have a delta-shape wing, with narrow, tapered, projecting surfaces on either side, which made the configuration after a three-pointed star—or, if one liked, a jellyfish. There was nothing to liken it to a jellyfish where performance was concerned, however, for the Swallow, as the aircraft is named, was designed to fly at Mach 2·5.

Mach 2·5 is equivalent to 1650 m.p.h. at a cruising altitude, which indicates how advanced the aeroplane is. Possibly of greater importance, is the way in which the aircraft has been designed to achieve this speed, and the way it has been made capable of flying for a non-stop range of 16,000 miles.

The principle behind this astonishing performance lies in the variable-geometry of the aeroplane, whereby the projecting wing surfaces pivot, to fold back after take-off,



and allow the aircraft to pass easily through the transonic flight régime until, quite easily, it attains Mach 2·0 and upwards.

This idea, together with the scheme for pivoting turbo-jet engines, which form the Swallow's power, was the brain-child of Dr Barnes Wallis, Chief of Aeronautical Research and Development at Vickers-Armstrongs (Aircraft) Ltd. Dr Wallis is so confident of the performance of the aeroplane that he has produced figures for it showing the aircraft might fly for eight to nine hours at the speed mentioned, carrying a crew and useful payload. He has overcome the problem of kinetic heating, that is caused by skin friction at high speeds, by employing a special system of cooling for the wing involving a vacuum method. He has thus taken several steps forward, but unless something is done about the ever-present problem of finance, his highly advanced conception will never become reality.

Up to the time when it was decided (probably unwisely) that there would be no further requirement for the manned military aeroplane, £1·5 million of government money had been spent on the Swallow. Much more is needed if the aircraft is to be built, but the British Government has withdrawn its support.

Hope for the Swallow lies in the fact that the United States authorities are extremely interested, and it may well be that the aircraft is given a new lease of life by American finance under the Mutual Weapons Development Programme. In exchange for such aid, Britain would allow a share in any civil applications that might come out of the Swallow.

A great future lies ahead for this revolutionary concept if it is allowed to reach fruition. The civil applications might be as profitable as any military; it would be disastrous to sacrifice a machine of such advanced design for economy reasons.

PHYSICISTS' TESTAMENTS

Because it is so much more interesting to do physics than to write about it, the number of books about physics by those who have contributed the major discoveries is always too small. This summer we have the good fortune to have two such books* appear.

For Bohr, the importance of physics is the opportunities which it is constantly offering for examination and refinement of our conceptual tools. He sees the essence of the development of atomic physics as the recognition of some feature of wholeness in atomic processes arising from quantising. The idea of this wholeness has penetrated in a disguised form to many spheres. Six of the essays in Bohr's book, dating from 1932 to the present day, are persuasive accounts of the essential unity of knowledge exemplified, for instance, in the relationship between physics and biology. He discusses the contribution which atomic physics can make to the problem of life and its understanding. In one of these essays he tries to place natural philosophy in its proper place in human culture. But by far the greatest interest in this book is in the remaining essay which originally appeared in 1949 in the Einstein volume of the "Living Philosophers" series. Here we have a very full description of the discussions which took place between Bohr and Einstein on the fundamentals of quantum mechanics. The starting-point for these discussions is the idea of the photon, the particle aspect of light. Although this proved a very useful concept, it lands us in a dilemma because of the difficulty of explaining interference. In looking at this dilemma, Einstein was always in a somewhat different position from the other great physicists of the century because, as Bohr points out, with his mastery for co-ordinating apparently contrasting experience without abandoning continuity and causality he was more reluctant to relinquish such ideas than anyone else. In 1922 the discussion was mainly centred on the Stern-Gerlach effect which concerns the spin of particles in a magnetic field. This effect presents great difficulties if we try to form a classical picture of the behaviour of particles. In 1922 the situation seemed rather hopeless to understand, but by 1927 the new quantum mechanics had appeared, and at an international congress in that year Bohr advocated for the first time his characteristic view of wholeness. He put forward the idea of complementarity—that is, the idea of two descriptions of a situation which are mutually irreconcilable but each of which has to be used to answer certain questions. In order to use such a principle, it is essential to realise that no matter what the phenomena concerned, the account of all the evidence must be expressed in classical terms. This crucial point, which became a main theme for the discussions between Bohr and Einstein, implies the impossibility of a sharp separation between the behaviour of atomic objects and their interaction with the measuring instruments. Later in 1927, Einstein was advancing his heretical view about wave mechanics in the case of a particle penetrating a narrow slit. The wave representing the particle is deflected so that we cannot predict with certainty whereabouts the particle will hit a photographic plate, but the difficulty which

* "The Physicist's Conception of Nature", Werner Heisenberg (Hutchinson); 184 pp.; 16s. "Atomic Physics and Human Knowledge", Niels Bohr (Chapman and Hall); 101 pp.; 32s.

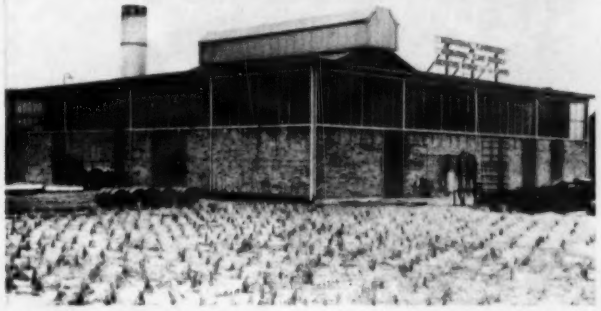
Einstein felt strongly was that if in the experiment the electron is recorded at one point of the plate it certainly will never be observed anywhere else, yet the ordinary laws of wave propagation do not provide for any correlation between two such events. In this case the discussions hinged very much on Heisenberg's uncertainty principle. It turned out that the experimental arrangement suggested by Einstein was impossible to assemble, not merely because of the practical difficulties but in principle. The position of the slit would be altered by a momentum transfer, and when we perform a complete analysis there is no inconsistency; but this example and many others which were discussed showed Bohr that it was essential that the whole experimental arrangement should be taken into account. In one case the result of this led to advanced inferences in the general theory of relativity, although the argument had started from a purely quantum mechanical level. The conclusion of the discussions is well known. Einstein's criticisms of quantum mechanics could not be sustained, but the importance of such a discussion is not its conclusion but the conflict between minds able to see to the root of any problem offered to them.

Heisenberg's book has only previously been published in German, in 1955. He starts roughly from the position at which Bohr leaves off. His avowed purpose is to examine the idea of nature in contemporary physics. He feels that even the artist and philosopher must take notice of the recent changes in the scientist's idea of nature. The principal cause of this change is Bohr's idea of complementarity. The naïve picture of an elementary particle as a minute billiard-ball cannot be sustained, and if we wish to picture the nature of an elementary particle we cannot ignore the process through which we have obtained our knowledge of it. Thus, the laws formulated mathematically in quantum theory relate not to the elementary particles but to our knowledge of them. Atomic physics no longer speaks of nature in itself, but of the connexion between man and nature. Heisenberg tries to relate this to wider considerations by considering the intervention of technology in the relationship of nature to man. The enormous development of technology leads him to picture the situation not as a result of a human effort to extend man's material powers, but rather as a large-scale biological process in which man's organic functions are transferred to his environment. If this picture is a reliable one, then this process removes the development from man's control. When technology is so advanced, Heisenberg says, modern man no longer confronts partners or rivals on the earth—disease, animals, natural phenomena are in a state of subjection; he confronts himself alone, but the dilemma is that this supremacy has been won at the cost of the loss of control. Even in science, we see the same process. We can no longer discuss nature in itself, but only our observations of nature. To make these ideas clearer, Heisenberg goes on to discuss the consequences of quantum theory and the development of atomic physics in the last few years. He begins by explaining the uncertainty relations with which his name will always be associated. From these we realise that the incomplete knowledge of a system is an essential part of any formulation of quantum theory. In the last two decades, the position has become a little confused. In contrast to the three elementary particles recognised earlier, we have a disturbingly large number. These mesons can change into one another during collisions at high energies. From this we may conclude, as Heisenberg believes, that there is only one kind of particle, existing in different discrete conditions. Since the energies involved in the collisions are high we must use the theory of relativity, and here we are in some difficulty because it it not easy to formulate consistently both the relativity restrictions and also the uncertainty relations of quantum theory. The best assumption at the moment is not a very satisfactory one, that in very small regions of space-time the notions of space and time become unclear, but it is too early to say whether this will lead to new paradoxes. In a second part of the book, Heisenberg gives a number of fairly lengthy selections from original writings which have shaped the course of modern science—Keppler, Galileo, Newton, and Huygens are represented by substantial extracts, and later writers by shorter ones. The thesis which he tries to sustain with these extracts is that the beginnings of modern science were characterised by a conscientious modesty. It made statements that were only valid within limitations. He believes that this modesty was largely lost during the 19th century. Today as he hopes, physics is undergoing a basic change, the most characteristic feature of which is a return to this self-limitation.

It is difficult to give any idea of how stimulating and exciting these two books are to read. One gets an impression of being present while a great man is actually thinking about a difficult problem. The translations are competent, and the printing of Heisenberg's book is extremely elegant.

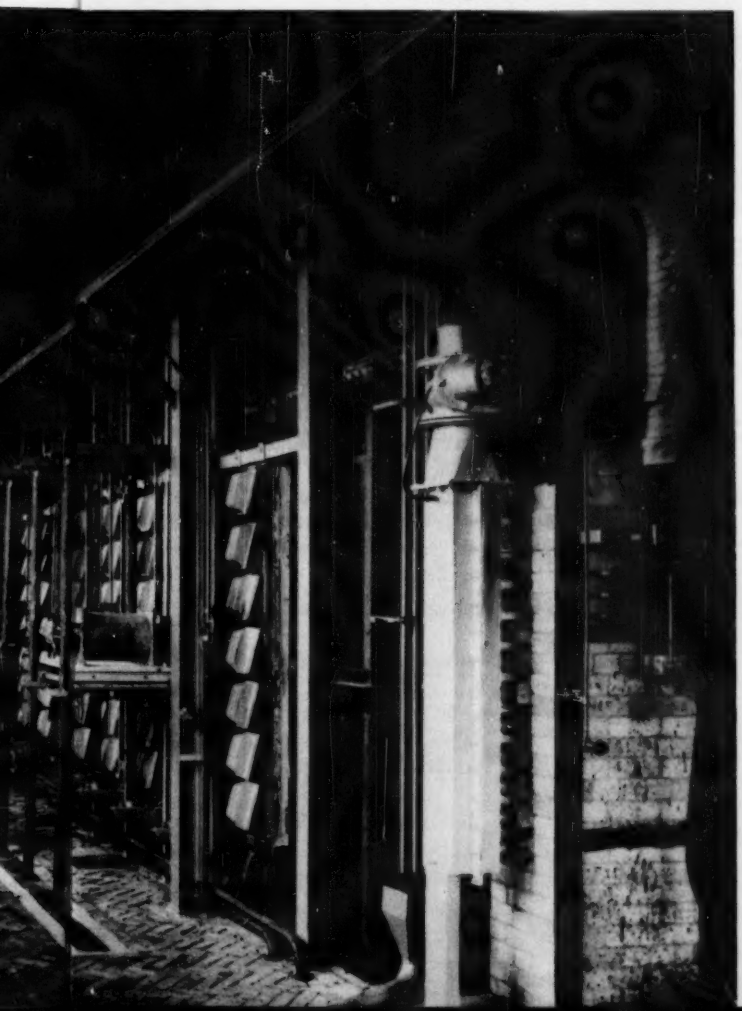
LARGE FLAMES AT AN INTERNATIONAL RESEARCH CENTRE

A very useful piece of international collaboration has been going on for the last seven to eight years at IJmuiden, on the Dutch coast. IJmuiden lies at the mouth of the canal by which big ships gain access to Amsterdam, and is the site of a large iron and steel works which is partly owned by the Dutch Government. Right inside the works are two modest-looking buildings bearing in three languages the notice, "International Flame Research".



(*Above*) The outside of the main experimental furnace building at IJmuiden. The name is given in Dutch, English, and French.

(*Below*) Tests being made on the pulverised coal furnace at IJmuiden. A temperature measurement is being taken with an optical pyrometer. The vertical bars are used to support the water-cooled probes and radiation pyrometers. One is seen in the foreground.



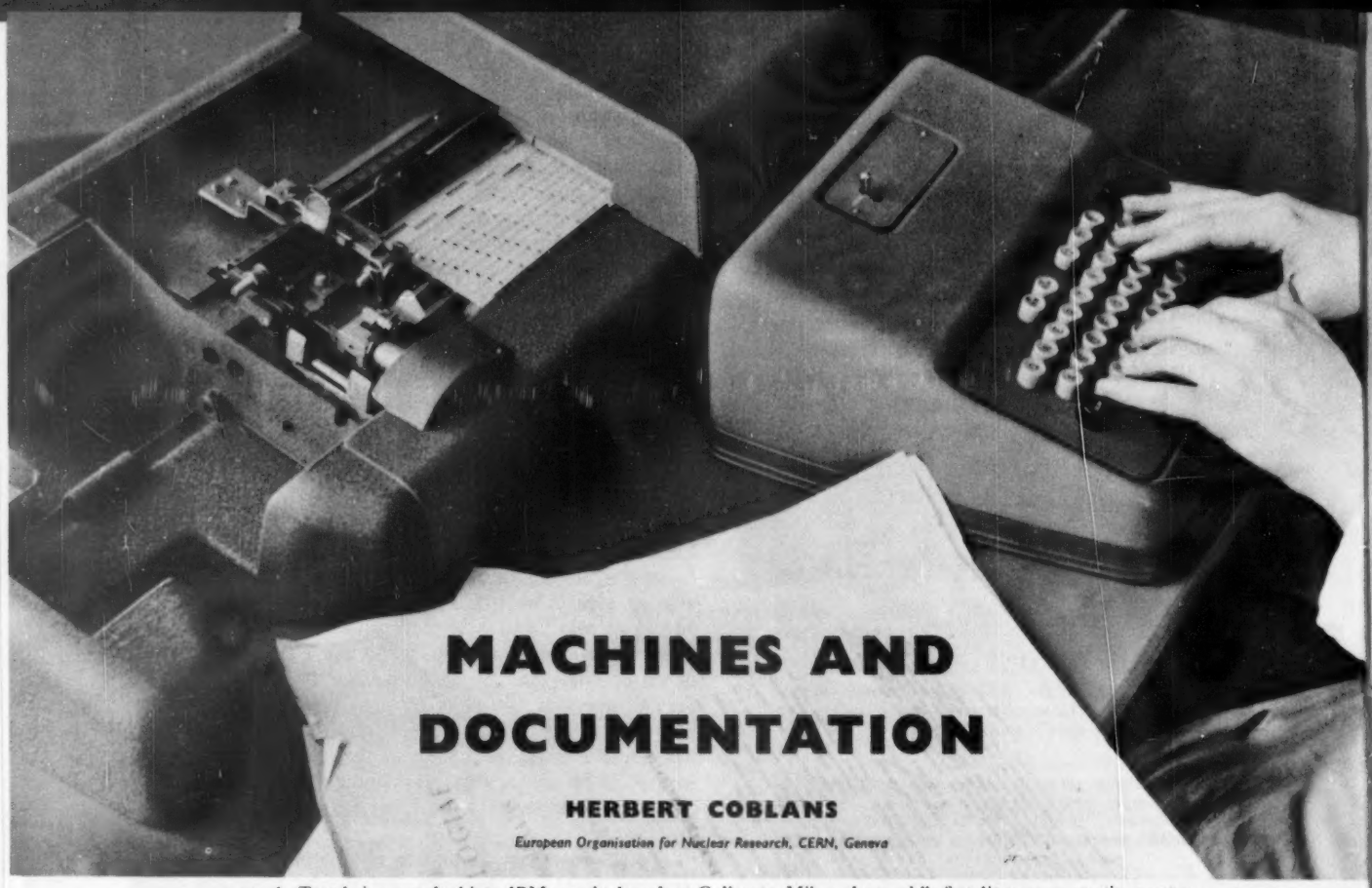
The history of this project is an interesting one. In 1949 there was a widespread feeling amongst fuel technologists that much more needed to be done to ascertain the basic facts about large flames—the kind of flame that is used in an open-hearth furnace, for instance, or a glass-melting tank. It so happened that in France, in England, and in Holland, *ad hoc* committees had been set up to organise research work on this subject, and credit is due to J. E. de Graaf, at that time head of the IJmuiden steel works laboratories, for his suggestion that this work might be done by the three countries jointly. An experimental furnace at IJmuiden was offered for the purpose, and it was generally appreciated that much more could be done in this way than by working separately. This kind of research can be very expensive, for some of these furnaces burn up to five tons of oil fuel a day. Moreover, when a trial is in progress, large numbers of scientists are needed to make the measurements and take the samples.

As it is at present, there are two experimental furnaces side by side. One (the longer of the two) is 10 m. long and 1½ m. wide, and is used for pulverised solid fuel. The other (6½ m. long and 2 m. wide) can be used for flames of oil or coal gas. Along both sides of each furnace, at regular intervals, are slots through which probes can be inserted or instruments sighted, and automatic travelling mechanisms move the covers of these slots up and down so that, as far as possible, no opening is made which could allow extra air to enter the furnaces, or hot gases to leak out.

The international committee now consists of six countries, for the U.S.A., Belgium, and Sweden have also joined it. The emphasis from the beginning has been on the radiating properties of flames, as that is something that cannot easily be predicted from experiments on a small scale. The actual radiant intensity from any one flame at any one point depends, of course, on its temperature and its emissivity; normally the same factor will affect both simultaneously. It is now realised that the existence of carbon particles in the flame is of great importance because of their high radiating power. Roughly speaking, the higher the ratio of carbon to hydrogen, the more strongly will it radiate. Rapid mixing will normally raise the temperature of such a flame but reduce the amount of carbon particles, and so the net effect may well be to reduce the radiation.

Much of the time at the Flame Research Centre is spent in either working out the results of the last experiment or preparing for the next. During this waiting phase there are nine scientists, of various nationalities, in the team on the site. For an actual trial, however, help is summoned from the various participating countries, and then additional personnel (normally about fifteen but sometimes as many as thirty) come to take the actual measurements. For the past three years the man directing operations on the site has been an Englishman, Dr E. H. Hubbard, but at the end of 1957 a French engineer, M. Kissel, took over.

The results of this work are published from time to time in the *Journal of the Institute of Fuel*, and corresponding papers in other countries. Since its inception, our knowledge of the properties of large flames has been greatly extended, and it is to be hoped that this promising piece of scientific team-work will continue for many years.



MACHINES AND DOCUMENTATION

HERBERT COBLANS

European Organisation for Nuclear Research, CERN, Geneva

FIG. 1. Text being punched into IBM punched cards at Gallarate, Milan, the world's first literary computing centre.

Since the Royal Society Scientific Information Conference in 1948 it has become widely accepted in scientific circles that an alarming situation is developing in the control of literature of the sciences. The position was already serious in the 'thirties. Since then the increase in the number of periodicals (and other serial publications like technical reports), the wide scatter of the literature on a given subject, the emergence of important periodicals in non-Western European languages, have all combined to create potential chaos in the 'fifties.

THE *MALAISE*

This was rather dramatically underlined last October when *Sputnik I* began to send out radio messages. Frantic efforts were immediately made to determine the frequency of emission. Actually the frequencies had been announced in Soviet periodicals in the months of June and July. The periodicals were available in the Library of Congress but the articles had not yet been translated. Recently an American "crash programme" in translations has been announced. This type of national action at best can only be a palliative. The *malaise* goes far deeper. Vannevar Bush, who was Director of the Office of Scientific Research and Development during the Second World War, has very neatly formulated the problem—"The progress of our civilisation in peacetime depends . . . not only on our current thoughts and findings, but on the skill and facility with which we create, store, interchange, consult and utilise the whole record of our collective past experiences." He goes on to say that in this vast record "we still hunt for particular items by horse and buggy methods".[1] The implication is that we should begin to use the new tools of communication engineering—punched cards, magnetic tape, and electronic computers. When a prototype machine, "The Rapid Selector", based on Bush's ideas was publicly demonstrated in Washington in 1949 there was much enthusiasm and optimism among documentalists. Today in spite of the advances in electronics and information theory the climate of opinion is much more agnostic and sceptical.

PLANS OF ACTION

Ten years after the Royal Society Conference there is to be a further attempt to pose the problems and consider solutions and plans of action. The U.S. National Research Council, the National Science Foundation, and the American Documentation Institute, are organising an "International Conference on Scientific Information" to take place in Washington in November. With the co-operation of the international world of science and documentation, seven categories of topics are to be discussed:

1. Requirements of scientists for scientific literature and reference services.
2. The function and effectiveness of abstracting and indexing services.
3. Effectiveness of scientific monographs, review media, etc., for the retrieval of scientific information.
4. Organisation of information for storage and retrospective research.
5. Problems in the design of new systems for storage and search.

A collection of spectra which can be selected according to chemical or spectroscopic data without the need for arrangement in order, or cross references.

Subscribers to the DMS receive a six-weekly "Current Literature List" giving the titles and literature references of all current articles of spectroscopic interest not yet published in the DMS literature card system.

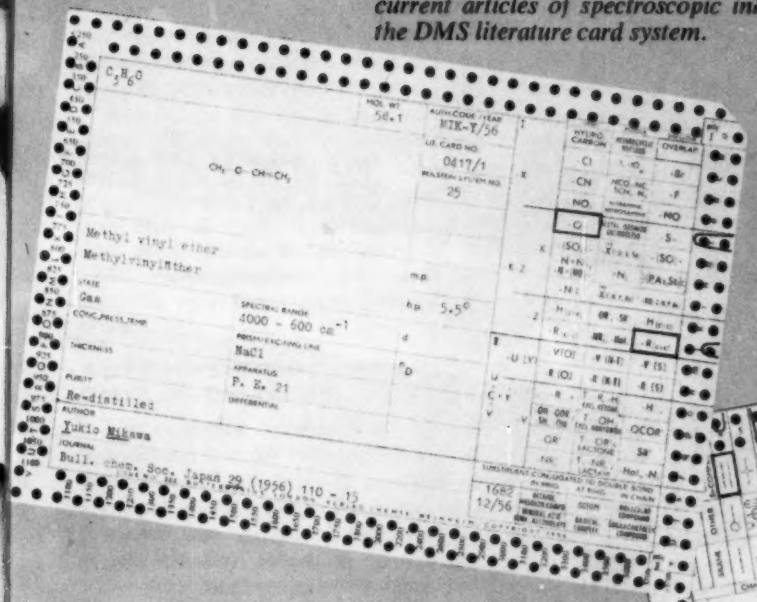


FIG. 2. The front of the spectral card gives the chemical characteristics of the compound, as well as experimental data and the source of the spectrum, or the journal of reference. The double row of holes on the right-hand margin permits selection according to chemical substituents.

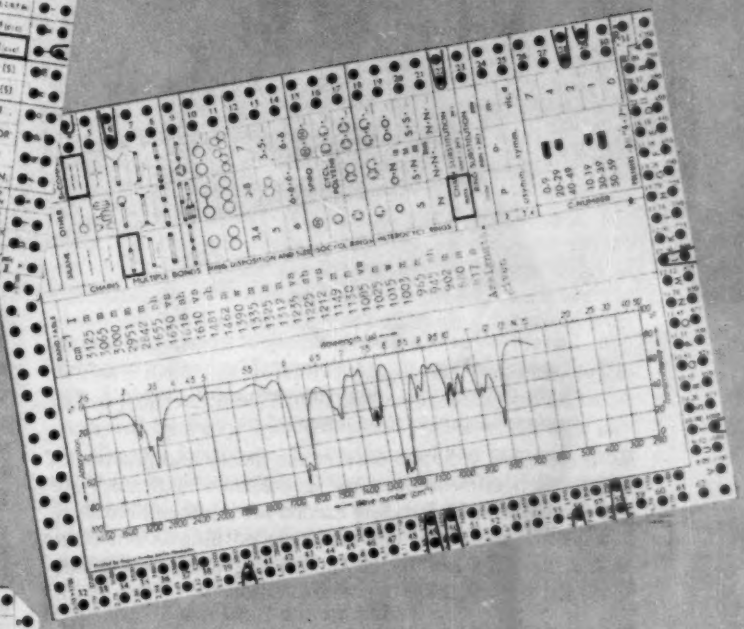
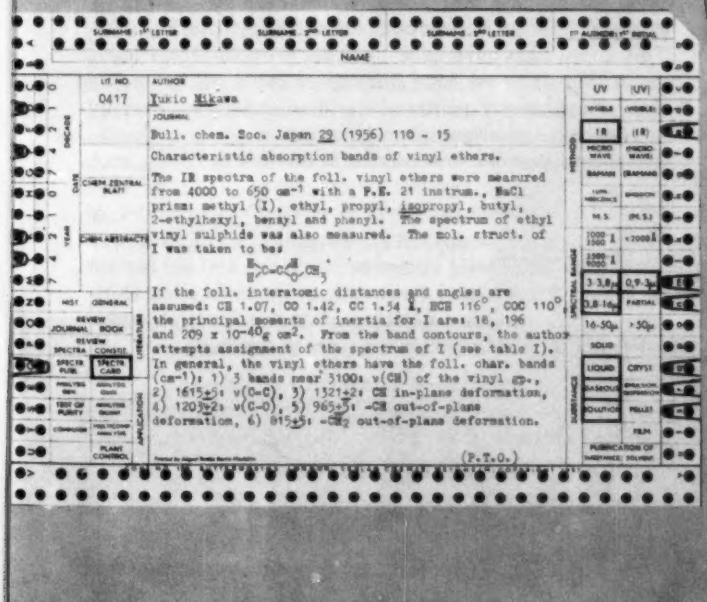
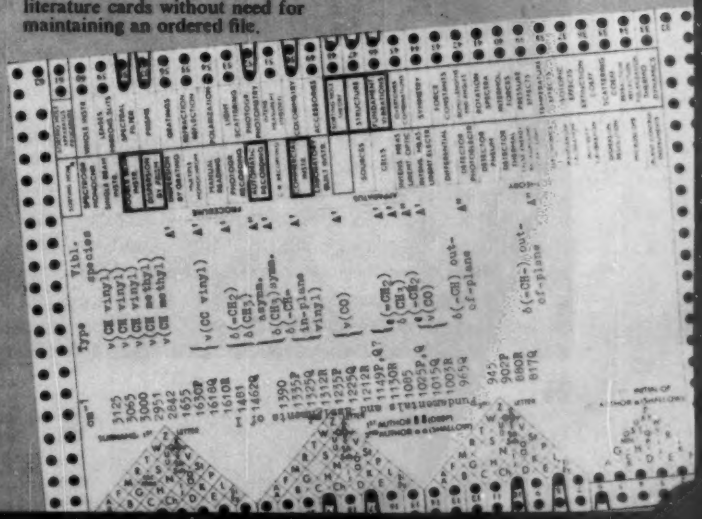


FIG. 3. The back of each spectral card shows the spectrum of the compound concerned in a standard form with accompanying band table. The marginal slotting on the three remaining sides permits selection according to basic chemical structure or by means of the eight strongest bands in the spectrum. Holes 26 to 30 on the upper right-hand corner code the number of carbon atoms in the molecule.



FIGS. 4 and 5. DMS includes an abstracting service concerning spectroscopy of published articles in compact form for easy reference. Each abstract appears on a card which is slotted according to the name of the author, the year of publication, and according to the content. The abstract required may thus be extracted from packs of literature cards without need for maintaining an ordered file.



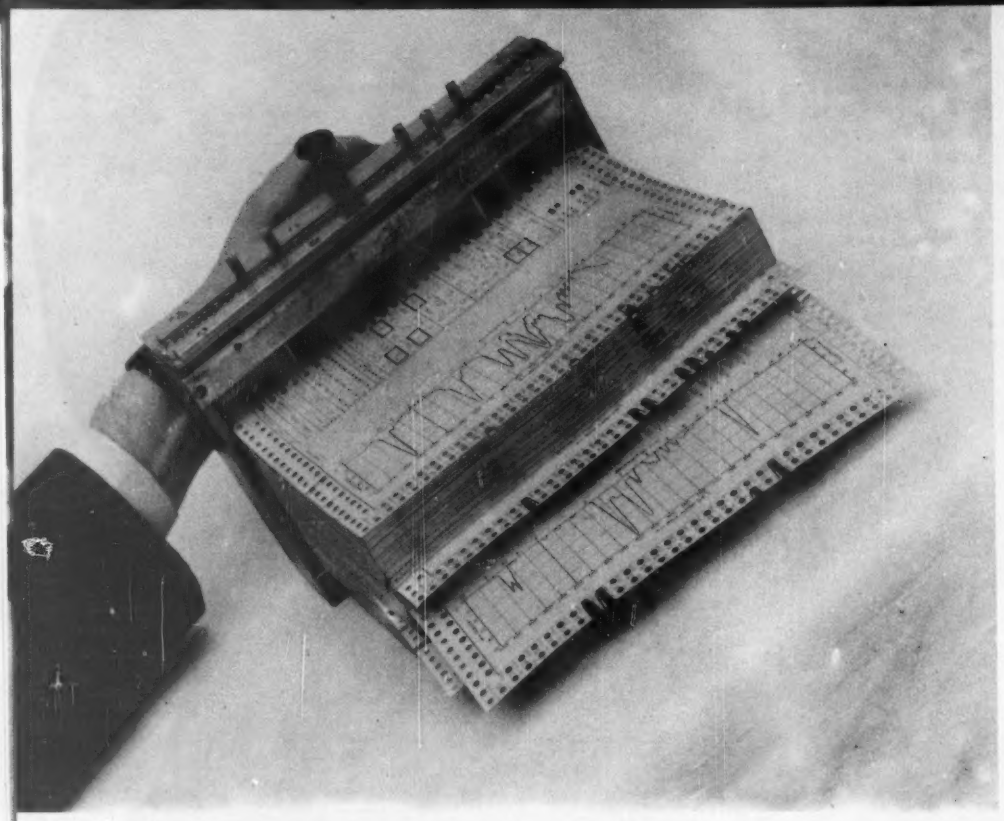


FIG. 6. Holder for DMS spectral cards. Needles inserted in the relevant holes of a pack (according to the keys printed on every card) prevent all but the desired cards from falling out.

6. Development of a general theory of storage and search.
7. Responsibilities of governmental and other organisations (universities, industry, etc.) for research and training in scientific documentation.

Of these areas 4, 5, and 6 cover the theory and practice of automatic documentation, that is, the machine devices and the classification and coding needed for input and retrieval. It might be useful to summarise the position in this field, that is, the principles of the various machines, their potentialities and present use in documentation.

THE EDGE-NOTCHED CARD

The devices, already in use or proposed, do essentially two things—storage and matching, for which the human analogues are memory and selection. This "data processing", to use the new jargon, is done in machines using either patterns of holes (the various type of punched cards) or electronic detection by light, magnetic signals, and so forth.

Punched cards were invented more than seventy years ago by Herman Hollerith, who successfully applied them to the U.S. Census for 1900. This method of mechanical recording and selection was later developed by International Business Machines (IBM) of New York and also by Power-Samas in England. During the last twenty years these commercially available machines have gradually come into use for documentation in highly specialised fields.

The simplest form of card, the edge-notched card using hand-sorting, is widely used by individual research workers especially for correlation studies. Bits of information are coded on to a card by clipping the correct hole so as to make a notch. For example, a group of American chemists wished to correlate chemical structure and toxicity towards insects. The properties of some 8000 insecticides were recorded, a card for each substance giving, say, name, chemical elements, solubility in certain liquids, molecular weight, chemical groups, toxicity index, etc. By repeated sorting with a knitting-needle according to the code plan, cards with any group of properties could be selected; for example, all the insecticides which are soluble in a given liquid, are solids at tropical temperatures, and contain a phenolic group. In principle these cards have not done anything which could not have been done with an ordinary index card. Suppose in the above example that thirty pieces of information had been coded on each notched card. This could also have been done on thirty different index cards. But then the total number of cards needed would have been almost a quarter of a million and selection would have become an overwhelming undertaking.

It is now possible to subscribe to services providing such notched cards for certain subject fields. Thus in 1956 Butterworths started issuing DMS cards (Documentation of Molecular Spectroscopy) in a joint project of the Infra-red Absorption Data Joint Committee, London, and the Institut für Spektrochemie und Angewandte Spektroskopie, Dortmund. They provide Literature cards and Spectral cards.[2] The latter answer the following types of questions:

What is the spectrum of a particular compound?
Which substances give rise to a certain band?
Which spectral characteristics are exhibited by a given structural feature?

THE MACHINE-PUNCHED CARDS

In principle the machine-punched cards serve the same purpose with the advantage that they are more efficient; that is to say, they hold more information per card, can be sorted rapidly by machines (about 500 cards per minute), and can, by the use of a tabulator or printing unit, "translate"

the data on the selected cards into readable form as a printed page. There is a vast literature[3, 4] on the manifold uses of machine-punched cards. A typical example is that of the Master Radio Frequency Record of the International Telecommunication Union in Geneva. Each week the ITU receives on an average some 275 notices of new assignments (or amendments) of frequencies. To check on the probability of undesirable interference a band of at least 10 kc/s wide on either side of the frequency notified must be consulted. "With the punched-card system, this information is readily obtained by the automatic transcription, on tabulated sheets, of the information punched in the cards for the frequencies or portions of the frequency band about which data are required, at the rate of 25 lines per minute."[5] Older manual methods just could not cope with the demands now being made on international radio communication.

AUTOMATIC DOCUMENTATION AT THE GMELIN INSTITUT

The examples mentioned so far refer to personal or institutional files for internal control rather than the documentation of large fields of recorded knowledge, which is our main concern here. There has been much written on proposed new systems of automatic documentation—the "machine-happy" future. As yet there are very few services beyond the initial stages of planning.[6] Of these a significant one is the Gmelin Institut für anorganische Chemie in Frankfurt. This institute is one of the few scientific centres devoted to only one task—the complete documentation of inorganic chemistry and allied fields and the regular publication of up-to-date editions of the *Handbuch der anorganischen Chemie*. In the past the method of compiling the Gmelin Archive file was to assemble abstracts mounted on index cards for all articles appearing in periodicals or other publications. The editors who are continuously preparing new editions of the handbook (the 8th edition of more than 100 volumes covers the literature till 1949) are given the relevant abstract cards and as many of the original papers as possible.

Subscribers to the service receive at regular intervals either dye-line copies of the cards in the desired subject classes or a selection of cards resulting from a search for a requested subject throughout the Archive file. It has recently been decided to mechanise this documentation by also encoding the abstracts on to IBM cards. Once this has been done the punched card file can be searched at much greater speed and according to more complex subject patterns. The cards found give the serial number of the transparent master containing the abstract, which can then be copied heliographically. Alternatively a copy of the original punched card can be supplied in each case. Such a service provides a valuable flexibility for the user. He can maintain his documentation by manual filing, or by machine collation, if machines are available; he can have additional copies of either type of card at a nominal charge and so build up special sets of cards in any desired subject grouping. The decision to introduce punched cards was a very serious one for the Gmelin Institut as it entailed a large capital outlay and a vast programme of encoding. It seems to have resulted from a conviction that automatic selection is the only way in which they can control their subject field and so maintain the established standard of the Gmelin handbook. The extent to which this mechanisation programme will justify itself is a matter of importance as it represents a sort of test case. Even if punched cards are found to be "efficient" for this purpose the success of this pioneering effort of the Gmelin Institut will depend on whether it will be accepted as *the* international service for these branches of chemistry. Only in this way can it become cheap enough for research workers in universities all over the world to use it.

There is an important advantage made possible by the use of punched cards. If the abstracts are suitably coded as suggested by Perry[7] they could be decoded afterwards into any desired language. Thus copies of the punched cards could be supplied regularly to national chemical centres (at least one in each country), where equipment is available. In this way a centre in Buenos Aires could give Argentinian chemists a Spanish version of abstracts of Russian papers which have been received in the form of punched cards from the Gmelin Institut in Frankfurt.

DATA STORAGE ON FILM

As the number of items stored in a mechanical system increases, a point is reached where efficiency is partly

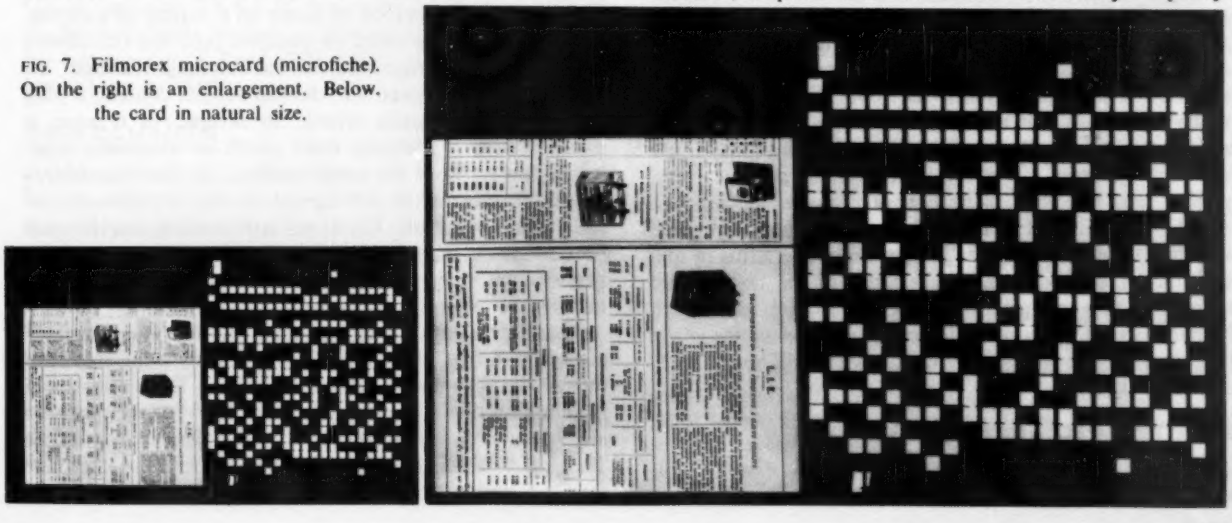


FIG. 7. Filmorex microcard (microfiche). On the right is an enlargement. Below, the card in natural size.

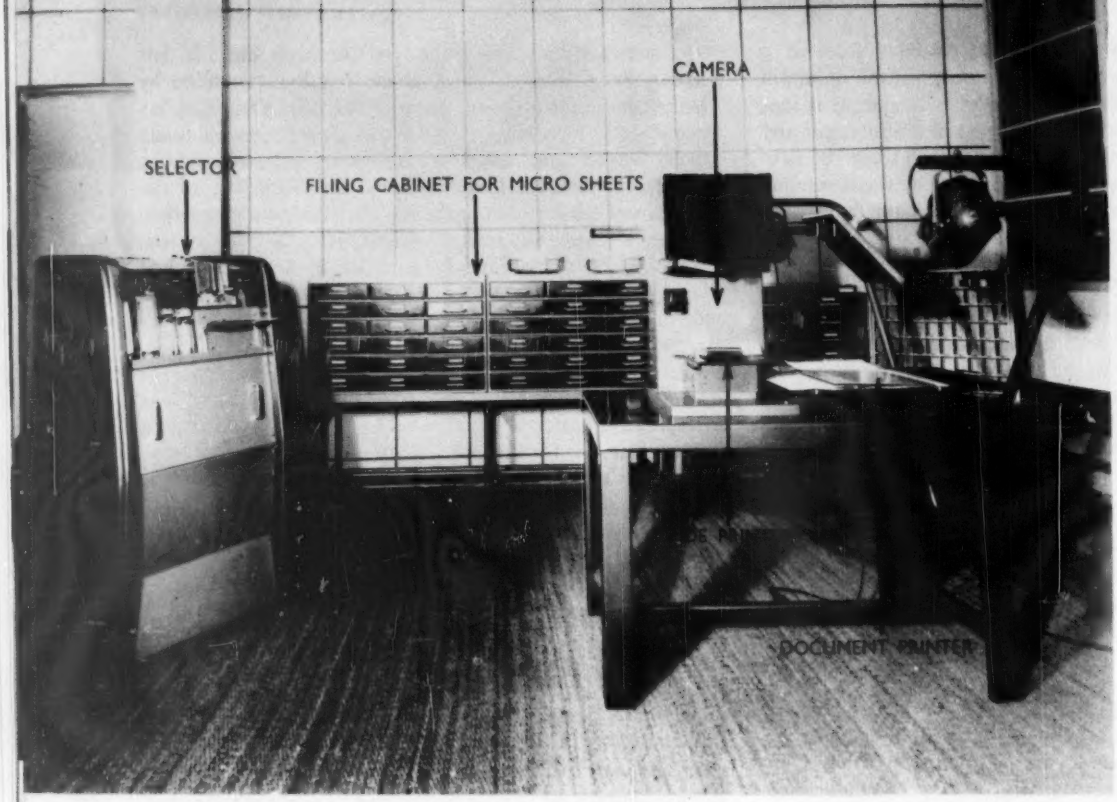


FIG. 8.
The complete
Filmorex equipment.

determined by sorting speed. Selection by photo-electric or electronic methods, in contrast to the essentially mechanical sensing of punched cards, can be done at speeds hundreds of times faster than the best IBM sorter. The photo-electric systems use microfilm as storage medium and the selection is based on scanning a pattern of dots. The most developed of these is "Filmorex", patented by J. Samain in France. He has been experimenting at the Centre National de la Recherche Scientifique in Paris since 1954; his machine is available commercially and has been installed in a few industrial laboratories. The original documents are microfilmed, for each two pages of text one micro-sheet (45 × 70 mm.). Each micro-sheet has two fields, one for the text, the other for twenty rows of patterns of spots, which permit the document to be given twenty different code numbers to represent its characteristics; author, periodical, subject headings, etc. Selection is done at a rate of 600 micro-sheets per minute, actually not very much faster than punched cards. The selected micro-sheets are read in a microfilm reader or can be used to make full-size enlargements. The complete equipment of camera, printer, and selector can be bought at a cost of approximately 2½ million French francs. The Kodak Minicard system[8] is somewhat similar in principle. The strips of film are smaller with very high reductions of the text so that storage is very compact. Sorting speeds are very much higher than for Filmorex. However, no decision has as yet been made as to when Minicard equipment will be available commercially.

ELECTRONIC SEARCHING

Systems based on electronic computers which could search a store of a million documents in two hours have been proposed. Electronic engineers can certainly construct machines to any such specifications, admittedly at an almost prohibitive cost. Whether such systems would provide an efficient method of retrieving information is still doubtful. Most of the projects are as yet in their early stages. The most advanced for documentation purposes is the WRU Searching Selector which is being developed by Perry and Kent[9] at the Western Reserve University in Cleveland. It was first exhibited in October 1956. It uses simple electronic circuits and thus only costs a small fraction of the price of a general purpose computer.

Each document is broken down into a specially developed telegraph-style abstract—a "machine language". This allows of subsequent searching for specific and generic terms and a combination of terms on a variety of patterns. These abstracts are coded on punched tape and transferred to any suitable storage medium, such as magnetic tape. To retrieve the documents with desired subject content, a plug board is appropriately wired. In reverse, as it were, a punched tape is obtained from which an automatic typewriter can type out the serial numbers of those documents whose characteristics correspond to the requirements of the particular search. Up to ten independent searches can be carried out simultaneously. The Searching Selector is part of a pilot programme of five years ending in 1960 and its ultimate value cannot as yet be assessed.

That bigger and better machines of this type can carry out comparatively complicated tasks of matching has been repeatedly demonstrated in recent years. The rather spectacular results of a project started in 1949 for the machine analysis and indexing of the "Summa Theologica" of St Thomas Aquinas were recently announced.[10] The compilation of a concordance of the works of St Thomas (approxi-

FIG. 9. Comparing the words of a modern scribe (the printing unit of an IBM 705 computer) with those written two thousand years ago by scribes of an ancient Hebrew sect living near the Dead Sea. Father Roberto Busa of the Aloisianum, with the help of IBM, is a pioneer in the machine analysis of literary and religious works.

mately 13 million words) would have taken fifty scholars some forty years to complete as against one year with the machine. Furthermore it is claimed that a large-scale electronic computer like the IBM 705 can be used for textual analysis. With suitable programming it can be adapted to reconstruct brief lost passages and even indicate spurious additions with greater dependability than any human scholar. Preparatory work is already under way at the Literary Data Processing Centre at Gallarate in Italy for the indexing of the Dead Sea Scrolls on the IBM 705.

The machine translation of languages is a related field in which the use of electronic computers is no longer a scientific curiosity. The principles have been proved reliable and pilot machines are in operation in Great Britain, the U.S.A., and the U.S.S.R.[11] According to W. N. Locke of the Massachusetts Institute of Technology machines should be turning out a good deal better than word-by-word translations by 1960.

CONCLUSION

Although punched card systems and electronic computers may be successful in handling the complexities of literary data processing and mechanical translation it does not follow that they are necessarily suitable in their present forms for the storage and selection of information over a wide range of knowledge. Machines are at their best when a large number of matching processes have to be carried out at great speed. To get relevant and valid information out of a machine presupposes that it has been put in with a most exacting pattern of forethought. In other words, without very great advances in our theory and practice of classification, machines are likely to be less suitable than the conventional manual methods combined with the associative faculties of a trained mind. On the other hand it can be said that fairly efficient automatic or semi-automatic systems exist (or are already in an advanced stage) for selection in narrow highly specialised subjects, where the concepts are well defined and terminology is standardised.

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THE CUBOMEDUSAE—LETHAL JELLYFISH

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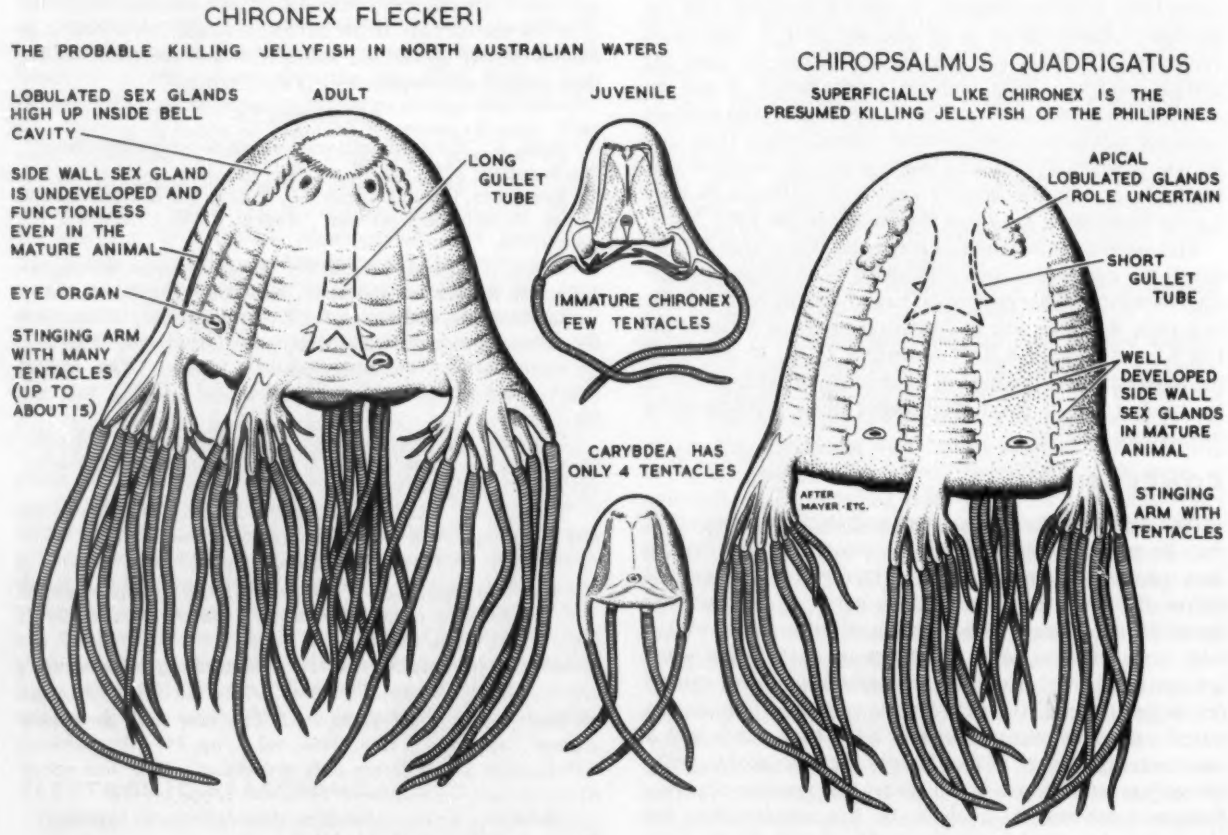
Deaths from jellyfish stingings have occurred for many years in the tropical Indopacific seas. The evidence incriminating the jellyfish responsible is largely circumstantial. Nevertheless, it points to the Cubomedusae as the lethal agents. One piece of evidence against the Cubomedusae is direct and indisputable. That was the capture of a Cubomedusa adhering to the victim, in a fatality at Darwin in 1938—a twelve-year-old boy.

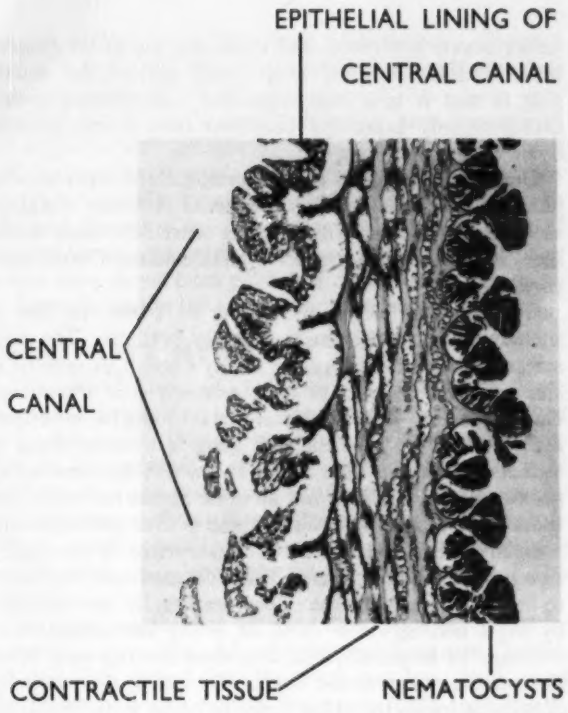
In the past this subject has been little studied. Thus practically no reference is made to it in textbooks of tropical medicine. Many medical and other writers blame such deaths upon *Physalia*, the Portuguese man-of-war or Bluebottle. Certainly, *Physalia*, one of the Siphonophores, can sting severely, as Bennett described in detail long ago. Despite its evil reputation, and the ease by which it can be recognised (its brightly coloured air-filled float bobs along the surface of the sea), there does not appear to be a single death recorded from a *Physalia* stinging. There is perhaps a little more evidence against *Dactylometra*, one of the Scyphozoa, but again this appears to be inferential rather than direct. The only other jellyfish with a very bad name for stingings is *Cyanea*. As far as the writer can determine, the only death recorded from it is in the fictional exploits of Sherlock Holmes.

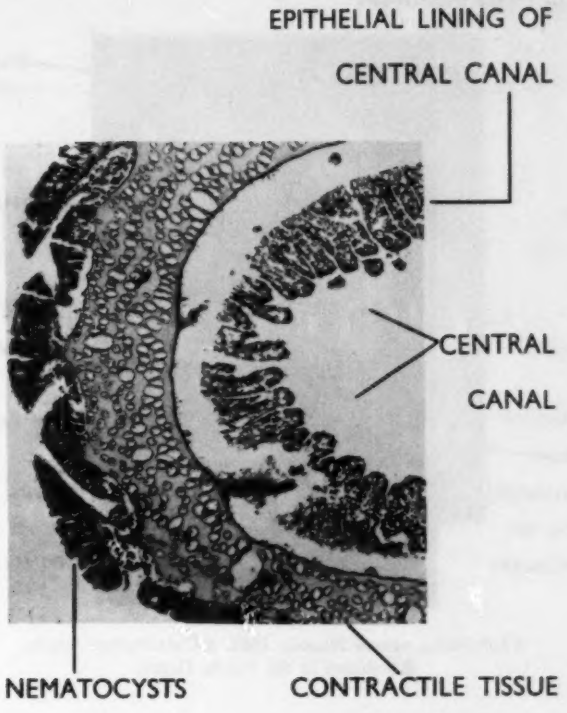
Until the last few years the greater part of our knowledge of these stingings came from the Philippines. They occur also in Malaya, Indonesia, and in northern Australian waters. It is only with the increased white population in northern Australian waters during World War II and in the years since that the subject has received any impetus. The native populations over this area do not seem to have much lore on the subject. Although certain natives utilise the Cubomedusae for food, it would appear in general they avoid them, and nobody has as yet learnt much about them from the natives.

THE STINGINGS

Both adults and children may be the victims, and usually have been healthy previously. The victim is in only a few feet of water. He cries out in great pain, and tries to struggle to the shore. Death may ensue in a few minutes, or may take up to about an hour. On the other hand, a number of bathers are stung under apparently similar circumstances, and may not suffer any more ill-effect than lines of wealing on the skin. In fatal cases the victim is







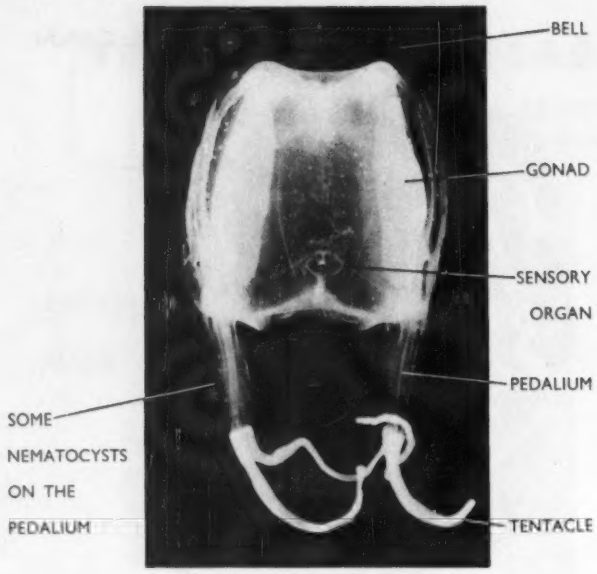
always marked prominently with red or purplish weals. Death in such cases appears to be due to acute cardiac and respiratory failure. There is nothing to support the views of some of the early writers that the death was due to drowning. Tentacles may stick to the victim, and are often described as cobwebby, or perhaps thicker. The rescuer of the victim is also marked generally with weals, but the effects are always much less, and no rescuer has succumbed.

Under the circumstances it is not to be expected that much attention can be paid to capturing or studying the agent responsible. It is occasionally seen, and usually described rather vaguely. This is, in fact, what one would expect with an organism that is practically transparent and which swims below the surface. The tentacles break off fairly easily. It is rarely, therefore, that the medusa is brought ashore. It is worthy of note that the victim may die in two to four minutes; that is, faster than from the bite of any snake.

THE CUBOMEDUSAE—STRUCTURE AND HABITS

These jellyfish are distinguished by the generally cuboidal shape of the bell. They sting severely, and from this the name "sea wasp" is often given to them. In Japan and the Philippines they are called the "fire medusae" in the native tongues. No good popular name has been given to them. Perhaps "box-jelly" or "jelly-box" would serve in English. The Cubomedusae are strong and graceful swimmers, and are thought to feed mainly on fish. The sexes are separate, and the eggs and sperm are liberated into the stomach cavity and are discharged through the mouth. These jellyfish are found in all the warmer seas. Thus they occur in the Mediterranean, in the Gulf of Mexico, in the seas of Japan, and in the South Australian gulfs, for example. In each of these cases a small species the size of a pigeon's egg occurs (*Charybdaea*).

At each of the four corners of the bell is a hand- or blade-like structure known as the pedalium, which carries the tentacles. Almost all of the smaller forms of Cubomedusae, and some of the larger, carry a single tentacle on the pedalium, and thus the animal carries only four tentacles. In the tropics, forms occur in which the pedalium carries a number of tentacles, up to about fifteen in number. Each tentacle originates upon a "claw", and the claws are arranged in either a linear or dichotomous series. The first illustration shows two species of these many-tentacled Cubomedusae, *Chironex fleckeri* and *Chiropsalmus quadrigatus*, which are superficially similar. The tentacles in life are much longer than the figures indicate. The tentacles are highly contractile, and on them nearly all the numerous stinging cells of the animal are placed. One may calculate roughly that a large Cubomedusa with a bell about 6 in. across, and with sixty or so tentacles, many of them about 6 ft. long or longer, could have about 200 ft. of tentacle available for discharge upon a victim (the apparent discrepancy in this calculation is due to the fact that the tentacles get progressively smaller farther out along the pedalium). It appears not unlikely that the amount of venom available is an important factor in the fatalities. Evidence from fatalities indicates that the victims of fatal stingings have received much less than the total amount of venom available, judging by the amount of wealing on the victim, but no precise quantitative data are available. As the reader will appreciate, there are many gaps in our knowledge at the present time. The actual killing species have not been identified with certainty, and little is known about the geographical distribution of *Chironex fleckeri*, beyond the fact that it is the principal (at least) large Cubomedusa of northern Australian waters, and is the probable cause of fatalities there. It is unfortunate that the 1938 Darwin specimen referred to earlier is extremely mutilated and



Charybdaea rastoni Haacke, 1886, a Cubomedusa widely distributed in the Pacific Ocean.

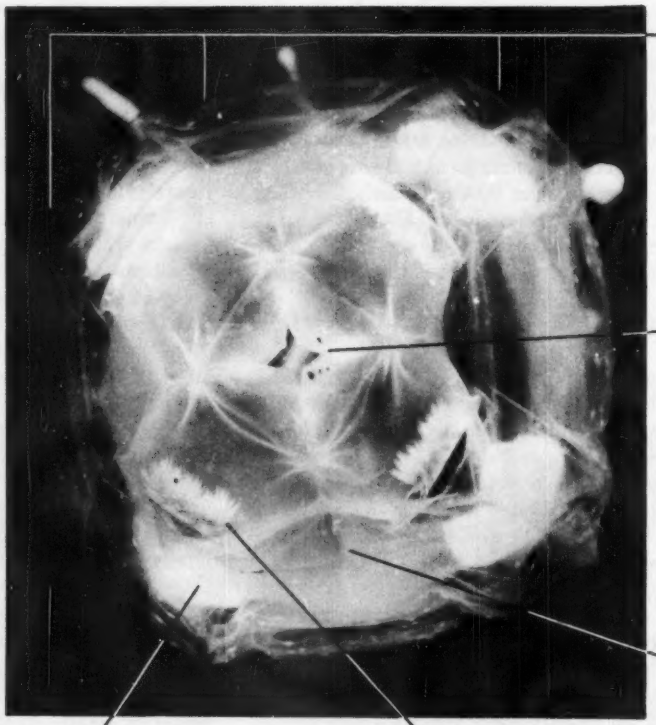
rather poorly preserved, and it has not, up to the present, been identified certainly as to genus, and all that can be said is that it is a many-tentacled Cubomedusa with a dichotomously branching pedalium (and hence is either *Chiropsalmus* or *Chironex*).

One striking point is the complete lack of any record of fatalities from Cubomedusae, or even of severe stingings, along the equatorial West African coasts. In those waters there is a large many-tentacled Cubomedusa, *Chirodropus gorilla.*

Cubomedusae generally appear to prefer to live in sheltered inshore waters, over sandy bottoms. The early stages of their life-history are poorly known. A number of students have worked at their anatomy and physiology. One of the most interesting features is the highly developed eye. On each side of the bell there is a sense organ or rhopalium, set in a little niche, and which contains both a position-sense indicator and an optic apparatus of six eye-spots. The most important of these is even provided with a biconvex lens. One is certainly surprised to see such a structure in a Coelenterate. The Cubomedusae are known to be quite light-sensitive. They are usually best captured by night netting, or at dawn or in the late afternoon or evening. In bright daylight they tend to keep well below the surface. One would expect, therefore, that with the dangerous forms the safest times to bathe would be in the middle part of the day. There is some evidence that overcast days are more risky.

THE TOXINS

In the Coelenterates the stinging cell or nematocyst injects the poison. Previous students have claimed to have



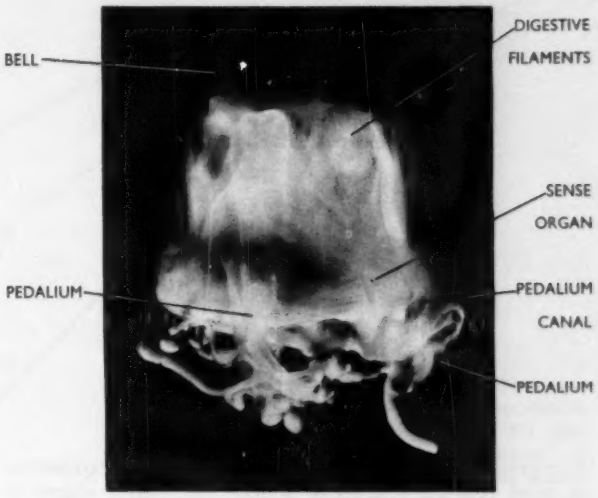
Charybdaea rastoni, same specimen from below

isolated various substances from nematocysts. All these studies have failed to separate nematocyst extracts from tissue extracts, as Hyman has pointed out. It is only recently that a technique of preparing pure nematocyst preparations has been developed, by Phillips. Whether it will be possible to separate out the various nematocyst fractions remains to be seen. Once the nematocyst has been obtained the toxin is easily obtained by the addition of distilled water. No results of the analysis of Cubomedusae venom have as yet been published. Such work is going on in Australia and in the United States at the present time.

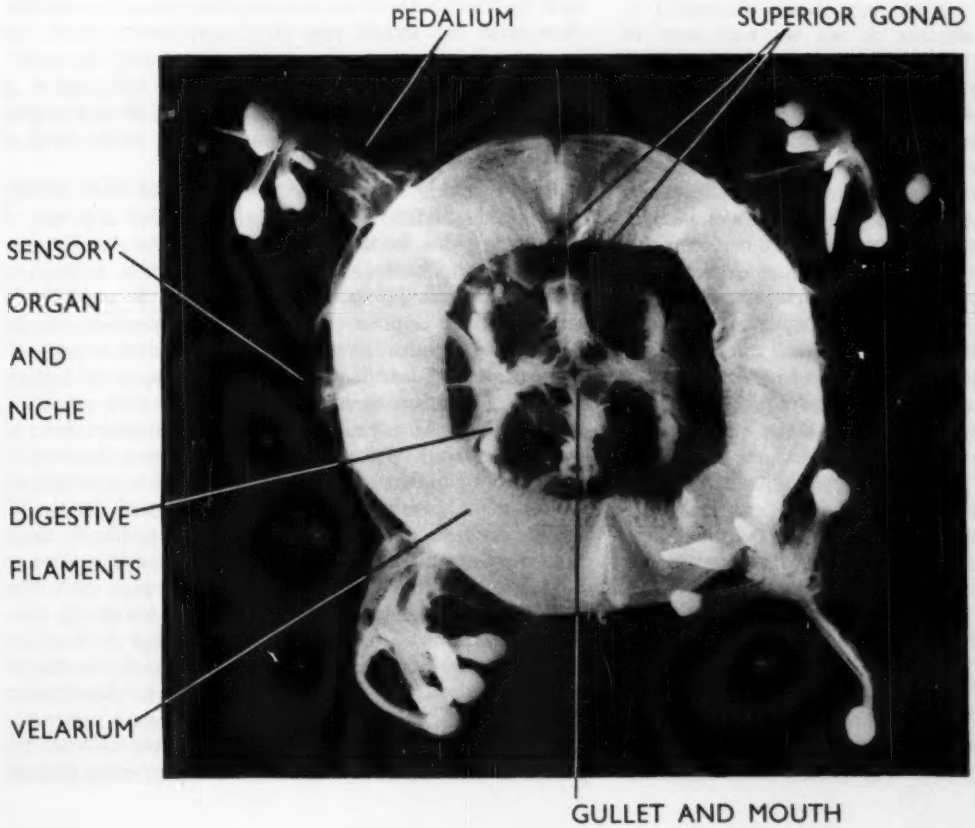
PREVENTIVE MEASURES

The possibilities of reducing the effects of these dangerous jellyfish at the present appear to be contained in the following: (1) avoiding or repelling them; (2) protection of the person by some mechanical barrier such as clothing or a greasy or oily substance (this includes also such a physico-chemical possibility as using some substance which could inhibit nematocyst discharge); (3) development of a prophylactic; (4) development of an antivenene.

Of these possibilities perhaps most hope is offered by numbers (2) and (3). All of them may have some usefulness. At the present time the safest way is to keep out of the water known to contain dangerous forms, particularly in calm seas and on dull days, or at any times except the middle hours of the day. In northern Australian waters the Cubomedusa *Chironex fleckeri* is dangerous from about November or December to about the following April. This is the period of the maturing Cubomedusa.



Chironex fleckeri, Southcott, 1956. Side view.



Chironex fleckeri from below. Specimen with tentacles removed.

THE MEASUREMENT OF UNCERTAINTY

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In everyday life we constantly have to choose between two or more possible courses of action, the relative merits of which seem evenly balanced and the respective consequences only dimly foreseen. Our decisions are therefore nearly always tempered by some uncertainty. A degree of doubt is manifested not only when we make decisions but whenever we express a preference, make an estimate, extrapolate into the future or interpret the past. Our beliefs are held with a degree of assurance which may range from gnawing doubt to unshakeable conviction. Whenever we are ready to carry out a task, although we are *not sure* of performing it successfully, we take a risk. An element of *risk* is present in spite of the fact that we may actually carry out the task perfectly: the risk arises out of state of mind in relation to the task. By contrast, we are involved in *hazard* if we are not always successful in performing the task, whether or not we were sure of success beforehand. Risk and hazard are thus independent of each other. We can take risks without necessarily incurring hazard, and we can incur hazard without necessarily taking risks. The study of subjective probability is the attempt to discover systematic tendencies underlying our uncertainties. When possible we can compare these tendencies with the corresponding *a priori* or statistical probability. Similarly, our private risks may be compared with patterns of hazard. Some of the ideas expressed in this article are the substance of a lecture delivered to the Mathematical and Physical Society, Royal College of Science, December 3, 1957.

The subjective conception differs both from the classical and the statistical conceptions of probability in that it is purely empirical and psychological. It is not based on the way a hypothetical "mathematical man" would behave. It may be applied, as de Finetti[1] has suggested, and as in fact we have shown, both to classical and statistical situations, but then the value obtained is not given by definition *a priori* or as an extrapolation from records of past events but as subjective impressions or predictions. But there are also forms of subjective probability which have no counterpart either in mathematical or in statistical probability.

THE PHENOMENON OF DOUBT

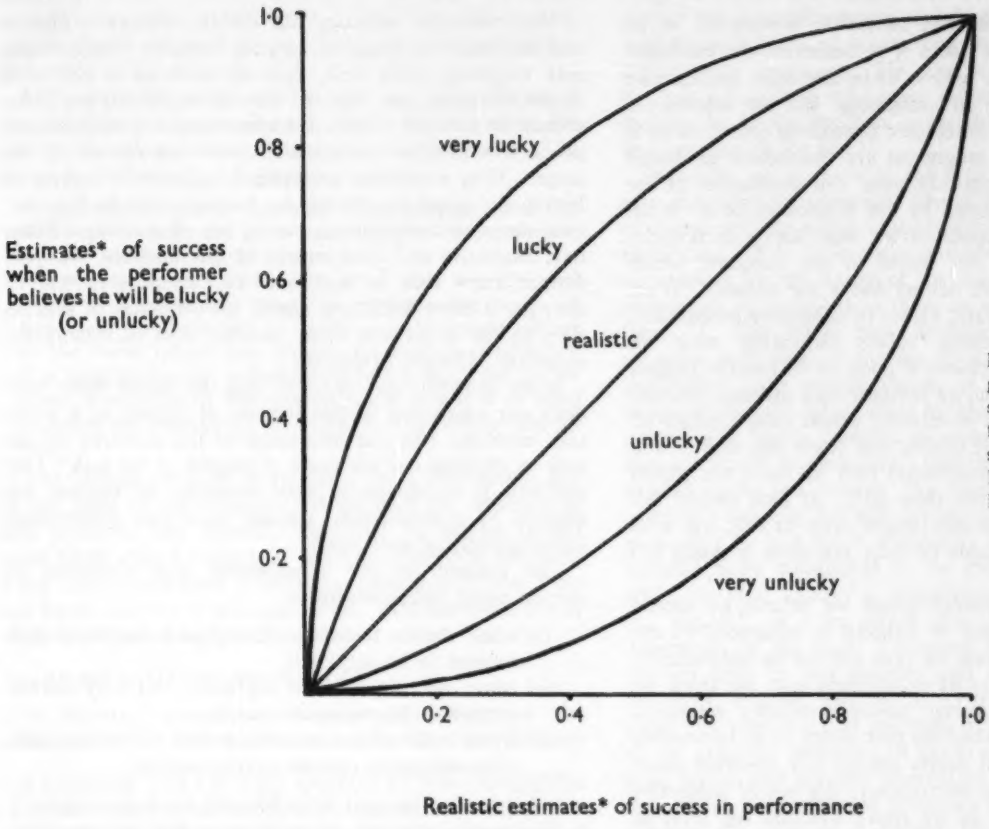
There is nothing new about the experience of uncertainty and doubt. It tormented religious thinkers of antiquity. In Zen Buddhism, doubting appears to be regarded almost as a criminal action, or at least as something to be carefully avoided since everything is "really" open to free observation and understanding. Thus the 9th-century Zen Buddhist, Lohan Hoshang, was no exception. He wrote:

> Wherever I went I met words and did not understand them.
> A lump of doubt inside the mind was like a willow basket.
>
> . . .
>
> He (the Master) then, baring his arm, gave me a blow with his fist on my chest.
> This all of a sudden exploded my lump of doubt, completely to pieces.[2]

In the Persian myth, Jung observes, Ahrimam, the Principle of Darkness springs from a doubt in the mind of Ormuzd, the Principle of Light. But as an idea with far-reaching implications for modern science, doubt appears on the scene in the 17th century. We recognise in the meditations of Descartes the first attempt to wrap private uncertainties in the robes of philosophy. For Descartes dreamed of erecting an edifice of knowledge on the solid rock of certainty. He succeeded in doing the opposite—in placing Doubt on the firmest of all foundations. Presently even the massive pillars of ethical dogma were to be shaken by tremors of doubt, in the shape of "moral probablism"—the idea that ethical decisions should be based on what we think is probably right according to the authorities we recognise. Escobar, a 17th-century Jesuit, believed that a penitent had to be absolved if he pleaded a probable opinion in support of his conduct. Various views were held by Jesuit authorities on such questions as, for example, how often one should love God: once before death was enough according to one, once a year according to another, and Escobar himself (Jung also tells us) held that it is sufficient to love God once at the awakening of reason, then once at quinquennial intervals, and finally in the hour of death.

Doubt came more fully into its own in the 18th century when it began its assault on the guarded citadels of Theology. This inspired Gibbon's proposal (as Keynes[3] writes) that a Theological Barometer should be formed, of which Cardinal Baronius and a Dr Middleton "should constitute the opposite and remote extremities, as the former sunk to the lowest degree of credulity, which was compatible with learning, and the latter rose to the highest pitch of scepticism, in any wise consistent with religion".

A more serviceable Occupational Barometer for our own days would be one which could measure the load of uncertainty people prefer to carry. At one end would be the perpetual doubters, the Buridan asses of the world, incapable of making a decision because they like to think that every question is evenly balanced; when they have to go for a walk they let their feet decide which path they should take. At the other end would be found the non-Buridan asses who have an irresistible urge to feel that their opinions are absolutely correct. Here we should expect to encounter the voice of Politics, for the characteristic badge of the politician seems to be an incapacity for doubt or suspended judgment. He must hold all his beliefs with a confidence of a hundred per cent because



Luck and realism: diagram to show the relationship between the performer's estimates of success when he believes he will be lucky (or unlucky) and his realistic, objective, estimates.

in so far as he lacked confidence in his judgment he would be implying that his opponent might be correct, and at all costs this must be ruled out.

MEASURES OF SUBJECTIVE PROBABILITY

Our first studies of subjective probability were concerned with the way people estimate, choose, predict, generalise, and so on, when the relevant information available to them is incomplete in various degrees. We have been specially interested in variations in these activities that occur characteristically with increase in age. The reason for this is twofold. First, we obtain thereby a more precise conception of mental development. Second, we learn to realise that our adult notions, which we tend to take for granted, do not make their appearance fully formed, like Minerva from the head of Jupiter, but pass through a series of distinct phases before achieving their final character. These studies have been described in a recent publication.[4] I shall confine myself here to a résumé of further experiments.

A simple measure of a person's subjective probability of success (or failure) in performing a given task may be obtained by asking him to estimate the number of times he thinks he would succeed (or fail) in, say, 5, 10, 100, or any other range of hypothetical attempts at the given task. The estimate is expressed as subjective probability by converting it into a fraction of 1·0. We employ the symbol ψ to denote a person's subjective probability, and various subscripts are added to distinguish different categories. When success is estimated, the measure is designated ψ_s, and when failure, ψ_f. It may be asked whether such estimates (and hence the subjective probabilities) are affected by the range within which they are made and, if so, whether the effect varies with age. We have found that values of ψ_s and ψ_f based on estimates made by children aged 9 to 10 years tend to decline with increase in the hypothetical attempts at the task. So at this age the estimates are not transposable, without a suitable adjustment, from one range of hypothetical attempts to another. The decline in the estimates is much less marked at the age of 13 to 14 years and is probably negligible in adults. Estimates made by adults within one range are therefore transposable to another.[5]

It may be asked further whether estimates of success and failure are additive. For example, if, suppose, I estimate my successes in a task to be carried out as "three out of five", would I have said "two out of five" if I had been asked to estimate my failures? Briefly, studies of children aged 9 to 14 years show that the mean values of ψ_s and ψ_f sum close to unity when they are based on estimates made within the range "out of five". They exceed unity when the estimate relates to a single attempt and they are increasingly less than unity at ranges greater than "out of five".[6]

EFFECTS OF FEELING LUCKY OR UNLUCKY

So far I have dealt with subjective probability in its realistic form: that is, when it is based on the estimates or decisions which we believe to be the most accurate we can make in the given circumstances. But our actions are commonly guided by unrealistic considerations. Indeed it may be that realistic judgments are themselves generated from a matrix of unrealistic ones, our evaluation of the "real" world being shaped by our phantasies of it. What we imagine would happen if we were lucky or unlucky may thus determine our belief in the outcome which would occur if we were neither lucky nor unlucky. If so, in addition to our realistic values of subjective probability, we should have limiting values indicating what we imagined we should achieve if good or ill fortune dogged our steps. For example, an investor may estimate realistically that his proposed investment would yield a return of, say, 5%. With luck, he thinks, this could rise to 8%, and even with the most exceptional luck he does not expect that it would yield more than 20%. If luck should fail him, the interest, he thinks, might drop to 3%, but with the worst luck imaginable he does not think it could fall lower than, say, 1%.

The level of performance which we believe we should achieve if we were lucky or unlucky is influenced by the degree of difficulty which the task has for us individually. When the task seems to us exceedingly easy we think we shall nearly always succeed, however unlucky we might be: and contrariwise, when the task seems to us impossibly hard we think we shall nearly always fail, however much luck we may have. At intermediate degrees of subjective difficulty of the task, as we move towards the level at which we are most uncertain of success, our lucky and unlucky estimates depart more and more from our realistic ones. When our realistic values of subjective probability for *different* tasks are similar, the corresponding values for lucky and unlucky values also tend to be similar.

A more direct measure of the subjective significance of luck and unluck may be obtained if the subject states how often in, say, ten trials, he would reach that level of performance which he believes he would achieve if lucky or unlucky respectively. We find that when adolescents estimate, for example, how far they could throw a tennis ball in a single attempt, their subjective probability, on the average, is about 0·5. This means that they think they could throw the ball this particular distance in some 50% of the attempts. The distance they could throw the ball if they were *lucky* they think they could achieve, on the average, in about 20% of their attempts, and similarly if they were *unlucky*. Finally, the distances they designate for *very* lucky and *very* unlucky performances they think they could achieve in 10% of attempts. The proportion of *occasions* on which they believe they would be lucky or unlucky is thus different from the proportion of *successes* which they believe they could achieve if lucky or unlucky. It would be of considerable interest to ascertain whether these results hold true for a wide variety of tasks, and what values they assume at other ages. If different tasks yield approximately similar values, this might imply the presence in the mind of a sort of internal "standard error" of estimate.[7]

CHANCE AND SKILL

Most tasks in everyday life involve subjective chance and subjective difficulty in varying degrees. Consider any task requiring some skill, such as throwing a dart at a target. Imagine, too, that the dart to be thrown has to be chosen at random from a set containing a predetermined proportion of blunt darts which could not remain on the target. How would the performer's estimate of success in hitting the target be affected by knowing that he has one, two, three, or four chances out of five of drawing a blunt dart from the set? Conversely, if, for instance, the performer knew that he had, say, two chances in five of drawing a blunt dart, how would his estimates of success vary as the target was made smaller, thus increasing the subjective difficulty of the task?

More generally the question may be stated thus: how does our awareness of the element of chance in a given task combine with our awareness of the difficulty of the task in affecting our estimates of success in the task? Our problem is to determine how estimates of success are affected by systematically varying these two components independently of each other.

The subjects in our experiments[8] give estimates of success under three conditions:

(i) when chance factors were negligible and only skill seemed to be involved;
(ii) when difficulty seemed negligible and only chance seemed to determine the result;
(iii) when both subjective chance and subjective difficulty seemed to operate simultaneously.

In boys and girls aged 13 to 14 years we find a tendency to give more optimistic estimates when they are considering two sources of uncertainty in one and the same situation than when the sources of uncertainty relate to two distinct and separate situations. The fusion of uncertainties in a single situation appears, at this age, to attenuate their effect on the estimates of success.

In further experiments[9] we find that the same apparent optimism appears whether the two sources of uncertainty both relate to chance or both relate to skill. The optimism seems greater in the former case than in the latter. Apparently, chance uncertainties, which stem from sources external to the subject and which are entirely beyond his control, have less impact than skill uncertainties, which he may feel are inescapably part of him. Young adults at the undergraduate age seem to be unaffected by this kind of optimism, for their estimates are much the same whether they are based on uncertainties in a single or in two separate situations.

UNCERTAIN WORDS

Husserl, that most precise philosopher, wrote that the sciences had lost the "Great Faith" in themselves, just as man had lost his "Great Faith" in reason. What did he mean by this? Did he, asked Ortega, have a "Little Faith" in mind with which the "Great Faith" could be compared? This is one of countless examples which could be given to illustrate the obscurity in our use of words or phrases which imply a magnitude or range of magnitudes. We have carried out various experiments to determine the magnitudes assigned, by children of different ages and by

adults, to words which are potentially quantifiable. These investigations demonstrate that the usage of such words is a function of age, and of the qualitative and quantitative context in which they appear.

The reader interested in this topic may be referred to the detailed articles.[10] Here I shall only stimulate the interest by citing two more examples of verbal doubt. The first is from Henry Fielding's "Tom Jones":[11]

> Jones now declared that they must certainly have lost their way: but this the guide insisted upon was *impossible*; a word which, in common conversation, is often used not only to signify improbable, but often what is really very likely, and sometimes, what has certainly happened: an hyperbolical violence like that which is so frequently offered to the words infinite and eternal; by the former of which it is usual to express a distance of half a yard: and by the latter, a duration of five minutes. And thus it is as usual to assert the impossibility of losing what is actually already lost.

The second example is provided by a 10-year-old girl in her reply to the question: "What does the sentence 'It will probably rain' mean?" She said: "It means: It will most likely rain, I suppose it will rain, I think it will rain, I am sure it will rain, I am not certain it will rain, I do not know whether it will rain or not, I should think it will rain, it will rain I suppose."

FURTHER DEVELOPMENTS

A bizarre instance of subjective probability is encountered in those suicidal attempts which, like Russian roulette, appear to be a gamble with death. The preparation of the suicidal attempt reveals that the suicide's subjective probability of succeeding in it may range from near-zero to near-unity. He acts in this fashion because he does not wish to take upon himself the sole burden of making the fateful decision, so he provokes "fate" to intervene and decide for him.[12]

However, we all have to learn to live with (since they are inescapable) ominous uncertainties of a political character without either exaggerating or diminishing their significance, and subjective probability presents a new perspective for the study of the way we perceive, think, and arrive at decisions in these as well as in other situations. It also offers new methods for pursuing such inquiries regardless of the age of the subjects or whether they suffer from mental disease or brain injury. In particular it provides a technique for the analysis of behaviour linked with highly complex processes. As an example, I may quote our investigation[13] into the effects of alcohol on risk-taking by bus drivers. We found that impairment of a driver's capacity for safe driving could be demonstrated even after he had taken a quantity of alcohol which had hitherto been considered to be too small to have any effect on road safety; a blood-alcohol concentration of 0·5 mg./ml. or even much less may make a driver dangerous on the road. Transport authorities and investigators both in this country and abroad (for example, Germany, Poland, and the U.S.) are now attempting to apply the concepts and methods of subjective probability to the practical problems of driver-selection and training, road safety, and accident-prevention. The practical implications for such different problems as decision-making in industry, the selection of students for higher education, and the study of the processes of senescence are also being examined. It seems clear too that there is much scope for the application of these methods to problems of rail and air safety, not merely in selection and training of personnel, but what is much more important, in determining the tasks assigned to human operators and the judgments and decisions which they are called upon to make.

GRADES OF VALUE AND QUALITATIVE CONTEXTS FOR THE FOUR CATEGORIES EMPLOYED IN STUDYING THE LANGUAGE OF UNCERTAINTY

In certain experiments the words or phrases were placed in a sentence and the subject was asked to interpret them numerically; for example, the subject was told, "Tom has *many* friends," and was then asked to say the *number* of friends he thought Tom had. In other experiments the subject was told to take "some", "many", or "a lot of" beads (or sweets) from a tray containing a given number. The actual number taken was then counted.

CATEGORIES			
*Quantity**	*Frequency*	*Duration*	*Likelihood*
hardly any	very rarely	in a moment	it is improbable that
not many	seldom	soon	may
some	sometimes	not long	probably will
many	often	for some time	is likely to
a lot	nearly always	for a long time	is certain to
QUALITATIVE CONTEXT			
friends	raining	raining	
trees	late for school	a person being away	political
			meteorological
stones	having a cold	time until Christmas	

* In the behavioural experiments the grade of value "some" was also employed.

FIG. 2.
Test for driving under the influence of alcohol.

Elsewhere[14] I have suggested certain implications from the study of subjective probability for educational practices and the problem of mental assessment. In particular, I should emphasise that the tendency to teach children that there are only cut-and-dried questions for which cut-and-dried answers must always be sought gives them an unreal picture of the situations they encounter in everyday life, many if not most of which are fraught with uncertainty. It also provides a poor preparation for scientific training later on when the student should learn to recognise his own doubts (or lack of them) which he is apt to project into his interpretations, as well as in the doubts arising from experimental error.

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[8] A full account will appear shortly in the *Brit. J. Psychol.*

[9] A full report of these further experiments will appear in the *Durham Research Review*.

[10] *See* Chapter 4 of "Risk and Gambling"; and "A Quantitative Study of Meaning", by the writer (with Dearnaley, E. J., and Hansel, C. E. M.), *Brit. J. Educ. Psychol.* (in press).

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[13] To be published shortly in the *Brit. med. J.* The investigation is a development of our earlier experiments described in "Risk and Hazard", *Operational Research Quarterly*, 1956, vol. 7, pp. 67–82.

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THE INTERNATIONAL HALL OF SCIENCE AT BRUSSELS

Although some pure science does feature in many of the national pavilions at the Brussels Fair—for example, the Czechoslovakian pavilion contains an excellent display of apparatus for polarography, and the British pavilion contains a fine model of ZETA—the main concentration of pure science exhibits is in the International Hall of Science. This is an excellent conception, designed to demonstrate the international character of science. Here will be found exhibits, from all the principal nations, designed to illustrate recent developments in pure and applied science without special regard to where and by whom they have been made. For the sake of unity the various exhibits conform to certain standards, but they are not standardised to the extent of monotony. By agreement, their country of origin is only discreetly displayed, although different countries vary considerably in their interpretation of this requirement. At the time of writing (beginning of May) the pavilion was not sufficiently complete to be opened to the public, but it was nevertheless far enough ahead for a good idea of its general scope to be gained.

The general impression was that the aims of the organisers have been achieved, and that in this pavilion we have a truly representative picture of recent scientific progress in all parts of the world. The exhibits are divided into four principal groups, respectively representative of the atom, the molecule, the crystal, and the living cell. They are, in the main, at a high scientific level—indeed, in some instances, perhaps at too high a level to be readily comprehensible to the general public. Organic chemical formulae, for example, are notoriously difficult to understand whether represented graphically or by models. Even for scientists without a specific training in chemistry they can be bewildering and they are likely to prove entirely incomprehensible to the general public. Nevertheless, for all those who have any sort of scientific background, this is a display of the greatest interest, and the layman too can certainly learn a great deal.

The Hall itself has been provided by Belgium, but fifteen countries have co-operated in furnishing the displays. The British exhibits compare well with those from other countries, and seem fully representative of progress in this country during the last twenty-five years. They include such diverse exhibits as a scale model of the Cockcroft-Walton laboratory, contributed by the Atomic Energy Authority; the structure of Vitamin B_{12}, which appears in both the crystal and the molecule sections; and models of various types of virus. Among contributions from other countries may be mentioned an excellent stand, prepared by American manufacturers, representing recent developments in antibiotic research; this includes many antibiotics so newly developed that their names are not yet in general usage. Of great interest, but doubtless likely to excite some controversy, is a stand from France illustrating the genetic effects on ducks of deoxyribonucleic acid. A particularly well-conceived exhibit was one demonstrating the Ziegler process for the manufacture of polythene. In this, one effectively saw ethylene gas passing in at one end of the exhibit, going through a variety of chemical manipulations to effect polymerisation, and the product finally passing into a press and emerging as stamped-out discs bearing the star-shaped symbol of the Exhibition.

MAGNETOHYDRODYNAMICS

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With surprising rapidity, a relatively new and somewhat obscure and difficult field of mathematical physics, which is described by the formidable title *magnetohydrodynamics*, has recently become of considerable importance. This is a branch of mathematical physics which concerns itself with the analysis of the interactions which can take place between an electrically conducting fluid and a magnetic field. The ramifications of this purely classical study in fluid dynamics and magnetism are surprising. The conducting fluids which have been studied include both liquid metals and strongly ionised gases, and it is in connexion with the latter that there appear to be exciting possibilities.

Perhaps the earliest success achieved by this mathematical approach (and this is but a few years old) was the formulation of a reasonable explanation for the familiar earth's magnetic field. An adequate theory for this has, up till recently, resisted all attacks. It has long been clear that the core of the earth is too hot for it to retain the permanent magnetism it was formerly thought to possess. Because of its high temperature, this core is in any case likely to be fluid, yet with considerable metallic content, and of sufficient electrical conductivity to lead to the possibility of magnetohydrodynamic effects. Indeed, the theory invoking this effect has satisfactorily explained both the regional and the secular anomalies in the earth's magnetic field.

However, very recently interest has switched strongly to the study of the magnetohydrodynamical interactions which can involve a variety of strongly ionised *gases*. Such ionised gas regions are called *plasmas* and are of importance especially in astrophysical problems. Thus, for example, in the recent annual report of Harvard College Observatory, D. H. Menzel proposes a new theory of sunspots based on such hydrodynamic equations. (See DISCOVERY, 1958, vol. 19, p. 187.) According to these equations, a gas at very high temperature, which is multiply ionised and so conducting, behaves in a rather more orderly fashion when in a magnetic field. Gas-flow *along* the directions of the magnetic lines of force becomes possible, but turbulence is strongly suppressed. Accordingly, the sunspots, which are regions in which ionisation is high, are to be regarded as *calm* regions, calm islands in an otherwise turbulent atmosphere. This is precisely the opposite to what has generally been considered to be the case.

Of equally formidable significance is the current intensive research in the application of this new magnetohydrodynamic approach to the treatment of thermo-nuclear discharge problems, of the type encountered, for example, with the ZETA apparatus. Since it plays a fundamental part here, it is not surprising that a symposium about it was held at Lockheed Missile Systems Division Research Laboratory, California, U.S.A., in December 1957. In the now notorious "pinch" effect which is, of course, the basis of the ZETA mechanism, the possibility of the existence of all-important plasma instabilities is being studied with the help of magnetohydrodynamic equations. At this symposium even some doubt was cast upon whether in fact the neutrons so far observed in the pinch discharge *have truly thermo-nuclear origin*, for it was suggested that maybe they are alternatively due to plasma instability effects. Clearly this matter is one of considerable urgency, especially to the whole international thermo-nuclear power project.

It is particularly in the field of astrophysical research that magnetohydrodynamical methods appear to offer very great promise. Already, for example, another problem being vigorously tackled is the analysis of plasma instability in *interplanetary* magnetic fields. The studies so far made in this connexion have already thrown some theoretical light on the known decay of the cosmic-ray activity which, it has been established, follows solar flares.

However, the principal interest of the symposium appeared to be directed towards laboratory experiments, of a variety of kinds. Apart from direct thermo-nuclear experiments there were others of much interest. For instance, a report was given on an analysis of the movement of a sphere in a conducting fluid which is maintained in a magnetic field, and drag equations have been derived. This is clearly of wide interest and indeed the theoretical predictions are under test now using the movement of small spheres in mercury, maintained in a magnetic field.

The shock-tubes, used so widely to study the dynamical properties of gases moving at very high speeds, lend themselves to study by a combination method in which the shock is produced in a gas between two electrodes, the plasma resulting being excited in a magnetic field. The interaction between shocks and solenoidal magnetic field is also being studied experimentally, and, of course, these studies are very closely related to the thermo-nuclear power project. There is, however, not the slightest doubt that other quite unrelated branches of both classical physics and astrophysics will reap a valuable new harvest from this new discipline.

The subject has already attracted quite a large number of expert mathematical physicists, and it is as yet only in the exploratory stage. One cannot resist remarking on how more and more the most recent and up-to-date developments in "modern" nuclear and atomic research and engineering have to lean increasingly on developments of long-established branches of classical physics. Our modern young research workers and students are impatient with the solid core of classical physics which forms the basis of our university degree courses. The cry is for atoms and quanta! nuclei and atomic reactors! wave mechanics and relativity! and away with "old-fashioned 19th-century classicism". Yet these young workers are very wrong indeed. The dynamics of gases, heat-exchange mechanisms, statistical fluctuations, and even old-fashioned electromagnetic theory, these and a dozen other branches of classical physics all now play basic parts in nuclear engineering development. Thus, had we more able classical physicists available, the rate of development would be much accelerated, and undoubtedly wastage in research much reduced.

It is clearly most important for our universities to see to it that there should be an adequate flow of physicists trained, for example, in the classical methods needed for investigating such aspects as magnetohydrodynamics, as well as in the more immediately attractive fields of nucleonics.

SCIENTIFIC ARCHAEOLOGY IN CHINA

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Considering the general consciousness of the past in China, it is only natural that the public would show great interest in archaeology. Although there has always been tremendous enthusiasm for ancient institutions and objects, the systematic and scientific study of these is of recent origin. The systematic study of metal and stone antiquities has existed since the 11th century A.D. But this was largely a matter of collecting and cataloguing the objects. A scientific study of such objects had to wait till the 20th century.

The problems of archaeology in modern China were discussed at a national conference on archaeology held in Peking in February 1956. Primarily there is a tremendous dearth of trained personnel. This becomes all the more apparent when excavations have to be conducted under pressure. This is often the case when, in the course of digging foundations for a building, objects are unearthed which are found to be of archaeological value, and the site has then to be hurriedly excavated. It happens most often in areas around the Yellow River (Huang-Ho), which are still very rich in deposits and remains from the past.

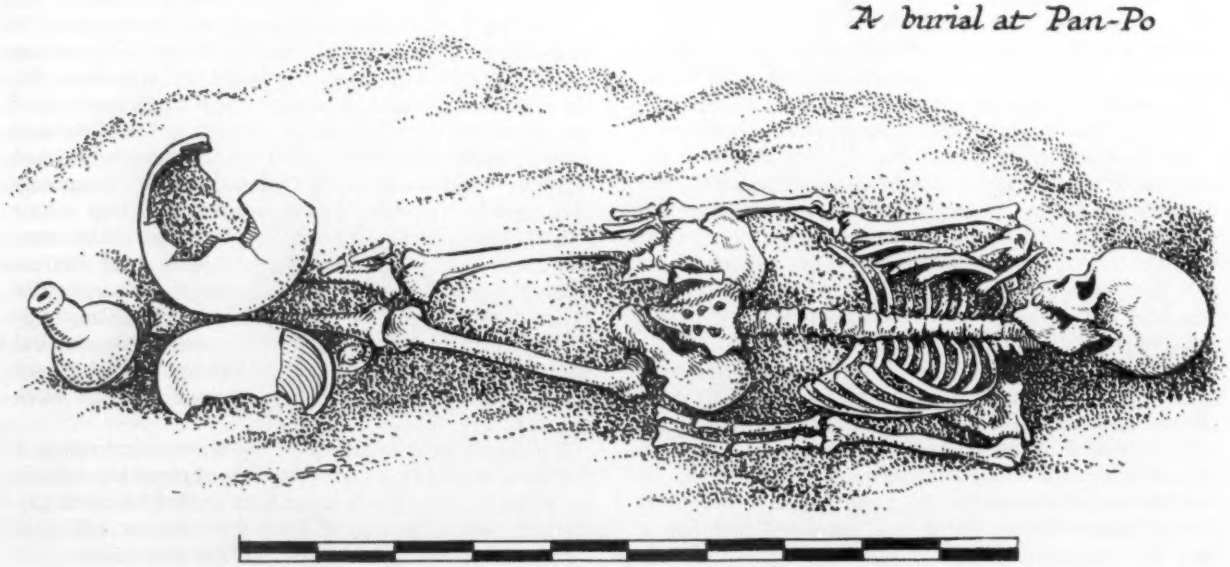
ARCHAEOLOGY AT CONSTRUCTION SITES

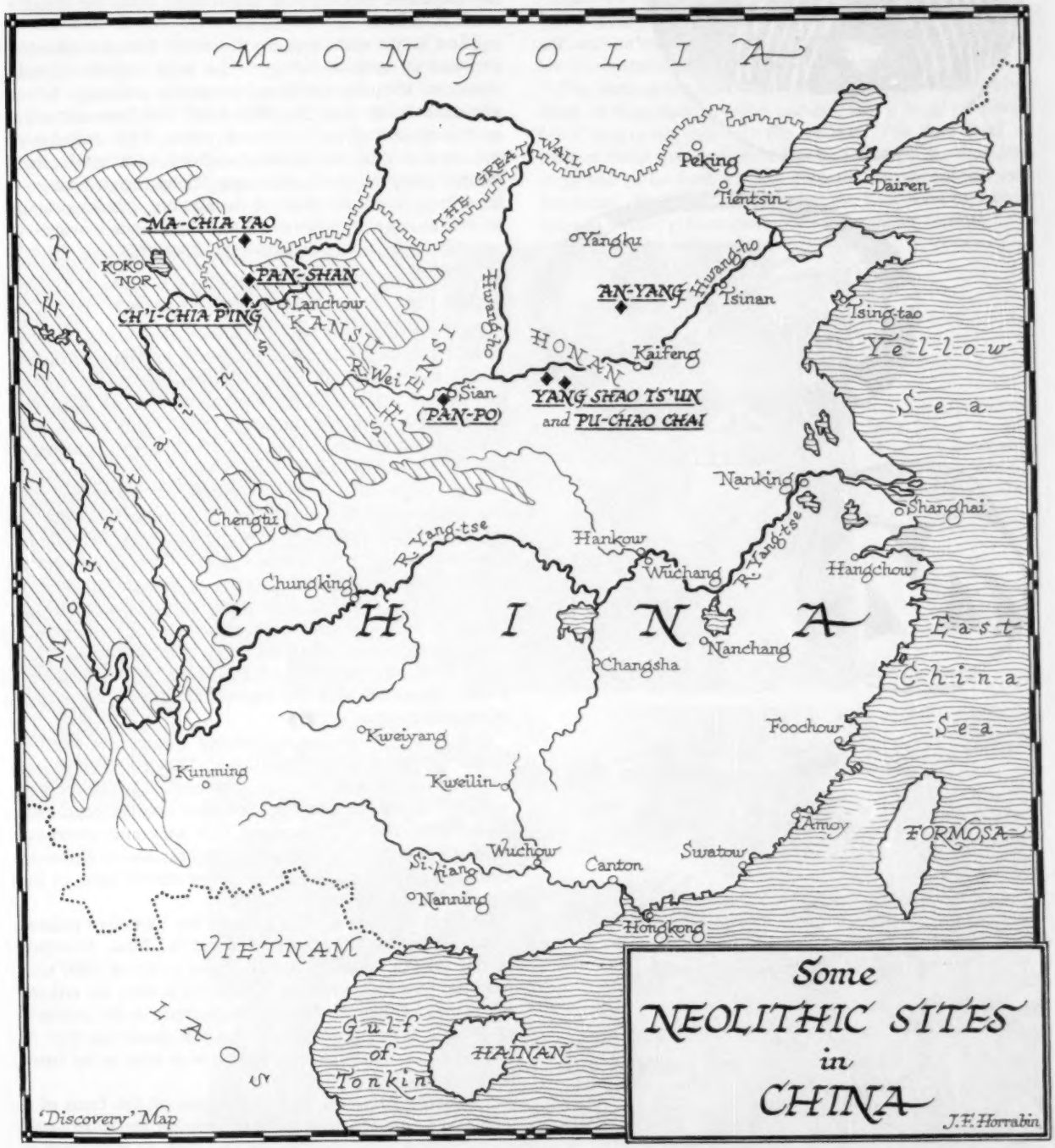
Because of the shortage of archaeologists, the Chinese have adopted another method of dealing with objects that are discovered outside of scientific excavations. Archaeology students of local universities are divided into groups, and each group is sent to work on a "construction site". By this term they mean an area where foundations are being dug and buildings constructed for some large project. Thus, each time a workman finds a pot, or whatever the object may be, embedded in the trench he is digging, there is always a specialist at hand to make a note of all the necessary details, and remove the object to safety. There is a large and excellent collection of Neolithic pottery in the museum at Lanchow, and most of it was collected by this method from "construction sites" in and around Lanchow.

This is certainly not as reliable a method of obtaining artefacts as that of a planned excavation. But if a museum collection can be built in this way, it can serve the very useful purpose of enabling students to handle the objects and become familiar with them. Considering that there was no museum in Lanchow five years ago, since there were no objects for exhibition, this procedure of collecting material cannot be dismissed as completely valueless.

The presence of archaeologists and students at "construction sites" serves the added purpose of acquainting the lay worker with the value of the artefact which he finds. If a workman is to be warned against smashing a Neolithic pot while digging he must be taught to recognise it and to realise its value. This acts, in the long run, as a process of infiltration, where interest in archaeology is not confined to the specialist. In rural areas this interest is created through local organisations of various kinds. Peasants are made aware of the possibility of turning up artefacts whilst ploughing. They are requested to bring these objects to the local authorities. If the objects are of value to the archaeologist, the peasant is paid some compensation and the object is placed in the museum. Very often these objects

FIG. 1. Pan Po. Grave showing skeleton and ritual pots used in the burial. The scale is 1 metre sub-divided into 10 centimetres.




MONGOLIA
THE GREAT WALL
Peking
Tientsin
Dairen
MA-CHIA YAO
KOKO NOR
PAN-SHAN
CH'I-CHIA P'ING
Lanchow
KANSU
Yangku
AN-YANG
Hwang-ho
Tsinan
Tsing-tao
Yellow Sea
HONAN
Kaifeng
R. Wei
SHENSI
Sian
(PAN-PO)
YANG SHAO TS'UN
and PU-CHAO CHAI
Nanking
Shanghai
Chengtu
R. Yang-tse
Hankow
Wuchang
Hangchow
Chungking
CHINA
East China Sea
Nanchang
Changsha
Kweiyang
Foochow
Kunming
Kweilin
Amoy
FORMOSA
Wuchow
Si-kiang
Canton
Swatow
Nanning
Hongkong
VIETNAM
LAOS
Gulf of Tonkin
HAINAN
Some NEOLITHIC SITES in CHINA
'Discovery' Map
J.F. Horrabin

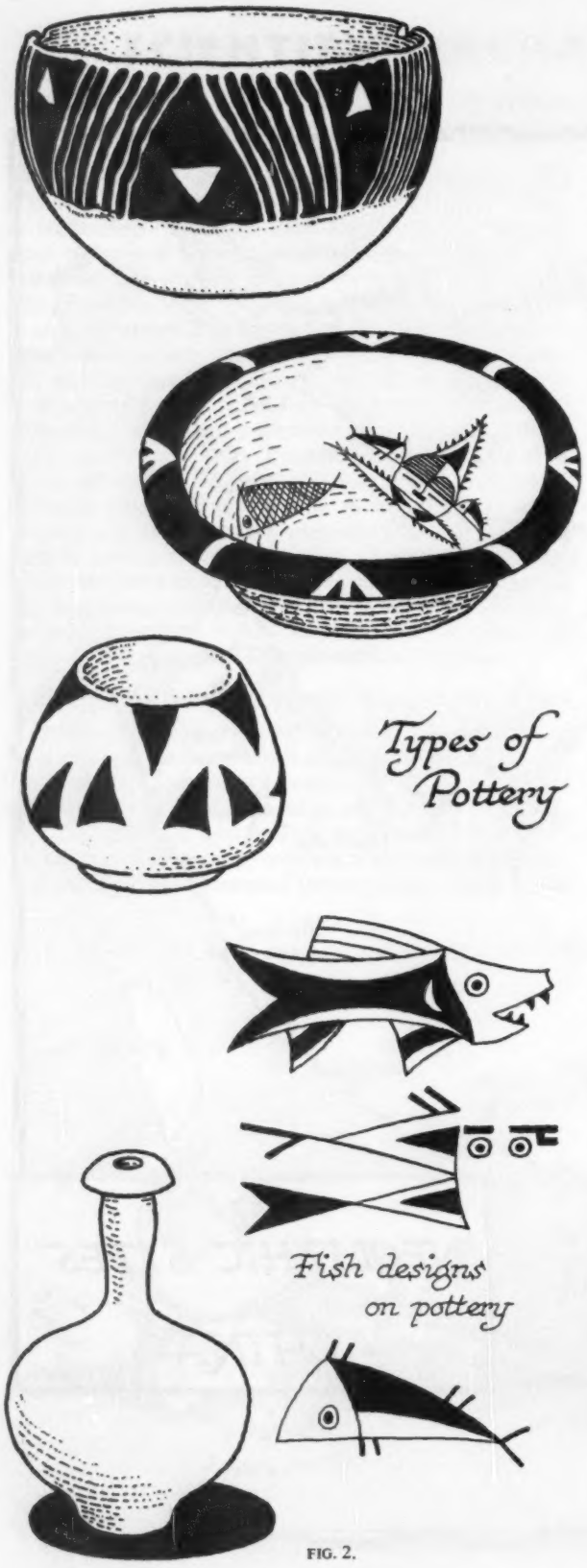


FIG. 2.

are donated by the peasants, who have no use for them anyway. In the small museum at Maichisan, in the province of Kansu, almost the entire collection of bronze and pottery objects has been donated by local peasants. Plaques bearing the name and date of each object carry the donor's name as well.

The Chinese make a sharp distinction between scientific archaeology and art-history. The latter remains closely connected with the traditional interest in antiquity. Scientific archaeology, on the other hand, has been attracting increasing enthusiasm in recent years. This enthusiasm can tend at times to become confused with nationalism. Nevertheless, the most encouraging thing is that even on a local level in distant parts of the country, the importance of archaeology is understood and appreciated, which is more than can be said of many other countries.

NEOLITHIC VILLAGE AT PAN PO

An interesting example of recent excavations in China is provided by the site of Pan Po, where an entire Neolithic village was unearthed. Pan Po is situated on the eastern outskirts of modern Sian. After a survey held in 1949 a number of possible sites had been located in this area. But it was not till the foundations of a textile factory were being dug on the site of Pan Po in 1953 that the pottery which emerged suggested a large-scale Neolithic habitation. This is a beginning common to many excavations in China. In the case of Pan Po the site when excavated was found to be important enough to be claimed as an ancient monument of national importance, and therefore an area under the protection of the Ministry of Culture. On this occasion the factory had to move elsewhere. Other sites of lesser importance are excavated completely, and then the area is built on as originally planned. All this is not dissimilar to the events connected with the excavation of the Temple of Mithras in London in 1952.

Pan Po covers an area of two and a half acres and lies on the right bank of the Chan River. Thus a regular supply of water was available to the settlers. The soil of this region is fertile loess soil, again conducive to a more permanent settlement. This points to a long and continued occupation of the site, and although there are no extensive signs of soil denudation, the better-preserved parts of the site reveal four levels of habitation.

The Pan Po habitation belongs to the Yangshao painted pottery culture of the Neolithic period in China. Evidence of this culture, which is usually dated to about 2500 B.C., has been found elsewhere in Honan and Kansu, the adjoining provinces, but this is the first example in the province of Shensi. It can now be said that this particular type of Yangshao culture was spread over a wide area in the basin of the Yellow River.

The date of this site was ascertained on the basis of a number of scientific tests. These included the more usual ones employed in most excavations such as radio-carbon dating and soil analyses. Because of the availability of bones it was possible to conduct flourine tests as well. As in most Neolithic cultures pottery provided a useful gauge for dating, both from a chemical analysis of the materials used for making the pots, and from the design and form of the pots.

HOUSES

The more distinctive features of this culture were the type of houses they built, their pottery and their methods of burial. The houses were either roughly circular or of a rectangular shape. The former were more commonly found in the early levels. Remains of the encircling walls have been found with evidence of post-holes. The average diameter of these huts was about 5 m. The walls were of a wattle and daub variety, and were from 5 to 10 cm. thick, rising to a height of about 22 cm., from which point the roof began. In excavating one of the houses a portion of the roof which had fallen in was discovered. It consisted of wooden beams covered with a layer of burnt clay, which must originally have been encased in a matting of reed, since reed impressions were still visible on the clay. The inner surface of the walls and the floor appear to have been finished with a thin layer of plaster. In the centre of each hut was a pear-shaped oven, surrounded on both sides with six post-holes arranged in pairs. This may have been the framework of a chimney-like structure leading out of the centre of the roof. The entrance was normally pointing south and was rather like a porch, about 70 cm. wide. Inside the hut the entrance was indicated by low partition walls.

The rectangular huts were built in much the same way. Most of them had rounded corners, and a large post-hole for a supporting pillar in the middle. The floor-level of most of these huts sank to a depth of about 1 m., therefore steps had to be built leading from the entrance down into the room. The purpose of sinking the floor-level may have been to ensure greater protection and greater warmth.

FIG. 3. (*Left*) Pan Po. Remains of a rectangular hut, showing sunken floor and pits for storing objects.

(All drawings for this article were made from photographs by T. F. Horrabin)

FIG. 4. (*Right*) Remains of a circular hut. The last remnants of the wall are visible above the pear-shaped oven in the centre.

POTTERY AND ARTEFACTS

The pottery used by the Pan Po people was of two types: fine and coarse ware. Well levigated clay was used for making pots and it was fired to a temperature when the clay turned orange or brick-red. Pots were hand-made and were either burnished or painted with designs in black paint. Designs were both geometric and zoomorphic. The depiction of the human face was also a popular design. Some of the latter designs carried fork-shaped and pointed decorations, the significance of which remains unexplained. Much of the fine ware in red, black, and grey was decorated with delicate impressions made with the use of thread or finger-nails. Shapes and sizes of the finer quality pottery varied considerably. Flat-bottomed vases, round-bottomed bowls, basins with overhanging rims, and long-necked bottles were all found on the site.

Pottery of the coarser variety, both red and grey, was usually made of clay mixed with sand. This ware was used largely for purposes of cooking and storing. Decorations were either cord decorations or a form of *appliqué* using pieces of clay to give the effect of a relief. Covers for these large vessels were usually made of the finer clay. Sometimes these covers were made to fit the jar, though often they were merely potsherds that had been chipped around the edges in order to fit the jar. Covered jars of this ware were found in some of the houses and contained grain which on examination was found to be millet. These jars were usually placed near large pits about 1 m. in diameter which are thought to be storage pits.

Clay was also used for the making of spinning whorls, balls (possibly used in a sling when hunting), scrapers (of the fine red clay), pottery rings, and hair ornaments.

Of the kilns excavated at the site there were two varieties. One had a pocket-shaped pit for a furnace, with an opening in the southern end through which the fuel was inserted and later the ashes were removed. The floor of the furnace over the fire pit was perforated. The pots were arranged on the floor and the heat came up through the flues. The second type of kiln was much larger and more popular. Here the furnace was in the shape of a cylindrical tunnel lying on its side. The floor lay across the centre of the tunnel. The heat came in through the side and into the lower half of the tunnel. It then passed through the perforations in the floor to the pots above. One of these kilns still contained several unfired pots of coarse clay.

Among other materials used for making artefacts, bone appears to have been very popular. Over 900 bone artefacts were unearthed at Pan Po. These included needles, borers, chisels, spatulae (possibly used as pottery dabbers), spoons, hoe-blades, arrow-heads, harpoon-heads, and fish-hooks. The needles of polished bone were either round or triangular in cross-section. Arrow-heads similarly were of various shapes, conical, flat, or triangular.

Stone tools appear to have been used quite extensively, and consist largely of axes, adzes, chisels, hammers, mace-heads, knives, and small balls. Mill-stones were also excavated. Very few of these stone implements were the result of flaking. Most of them were made by polishing and friction. Unfortunately a large number of the stone tools found at Pan Po were broken. A curious feature about the stone axes was that those at Pan Po tended to be oval in cross-section, whereas those found at other Yangshao sites in Honan, for instance, were found to be square in section.

The use of cloth must have been known to the people of Pan Po because of the evidence of spinning whorls and the imprint of cloth on pottery vessels. The use of metal, however, was unknown to them.

BURIAL CUSTOMS

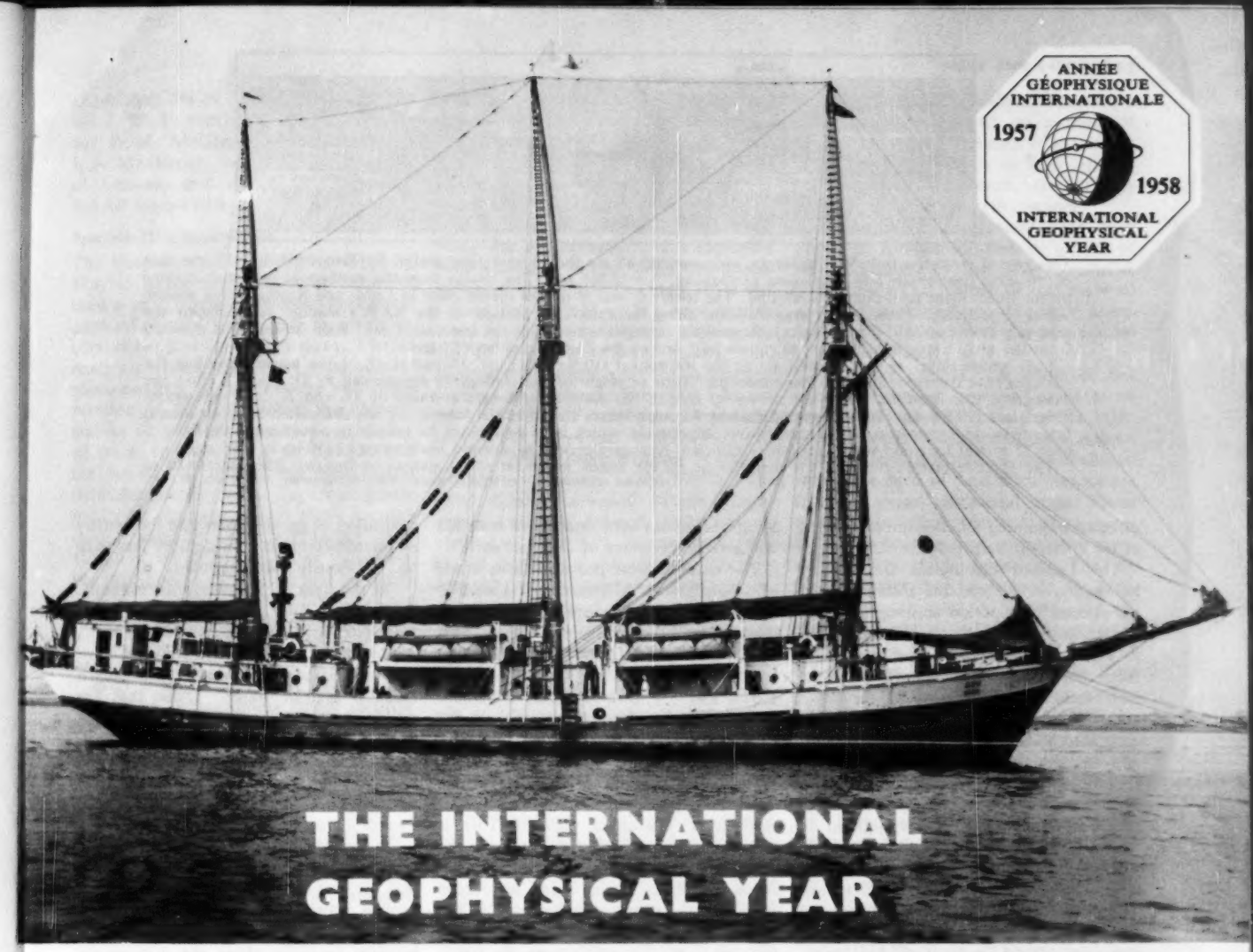
The final factor of importance in this culture was that of burial customs. Here the burial of children differed from that of adults. Children were buried in jars made of the coarse ware. Each jar was perforated at the bottom, and at the top the opening was covered with a small bowl of fine red pottery. Some of these jars were found grouped together in small cemeteries.

The cemetery for adults was in a separate part of the site and about 130 tombs were excavated in this area. The tomb pits were rectangular and went down to a depth of an average of 2 m. Each grave contained a single corpse, laid out in an extended position. This is again at variance with the Yangshao tradition where corpses were usually buried in a flexed position. In the Pan Po graves five or six pots were usually placed near the feet of the corpse. These pots were of varying shapes and sizes and were examples of the types of pottery in use among the people, coarse jars, fine bowls, small-mouthed bottles, painted vases with high necks, and fine pots covered with finger-nail impressions. The pots were no doubt connected with a ritual observance. One of the tombs contained an unusual waist-band made of bone disc beads. In the same tomb an ear pendant of green stone had been placed near the ear.

Most of the extensive excavations on Neolithic sites in China are concentrated in the Yellow River area. The excavation at Pan Po has certainly extended the region of Neolithic habitation in this area.

Of even greater interest from the point of view of comparative study are the excavations of Neolithic sites in other parts of China, which Chinese archaeologists are at present working. Artefacts from four tombs believed to belong to the Neolithic period, and located in the coastal area of Fukien province, have produced interesting evidence of burial rites of the Neolithic people. In the Kingshan area of Hupeh, botanists are busy working with archaeologists on a Neolithic site, where rice-husks were discovered mixed with clay used for building purposes. These husks are believed to be 4000 years old and when fully examined may reveal the knowledge of rice-planting in China, in a period as early as the Neolithic.

(The above article is based on material to be used in a book on recent archaeological development in China, to be called, "Journey to the Corn-rick Mountain", by de Silva, Vigier, Thapar, and Darbois.)



THE INTERNATIONAL GEOPHYSICAL YEAR

The Russian non-magnetic ship *Zarya*, which is on a round-the world cruise to make measurements of the magnetic field of the Earth's surface under the IGY programme. She is the only ship of her kind and has already observed a number of variations not previously marked on magnetic charts. This picture was taken on the *Zarya*'s recent visit to Britain. *See also* DISCOVERY, 1957, vol. 18, p. 439.

Additional Ionisation Discovered

What precisely happens to the ionosphere during a radio "blackout" at periods of maximum sunspot activity such as that chosen for the IGY? While the blackout lasts, the pulses from vertical incidence recorders (the standard method of checking the height and activity of the ionised layers) are not reflected as usual but absorbed. That this absorption must be caused by increased ionisation in the lower atmosphere had been proposed long before the beginning of the "Year"; to establish this conclusively, however, required refined rocket sounding techniques. This the American IGY programme has been able to provide in the DAN rocket flare patrol conducted from Point Mugu, California, by the Electron Optics branch of the Naval Research Laboratory under Dr Herbert Friedman, and in the *Aerobee* flights from Fort Churchill, Canada.

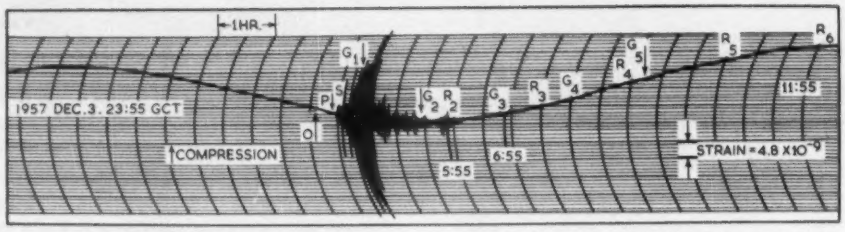
Last July 4 while conditions were still much disturbed following the large solar flare of June 28, radio signals received from a rocket fired through the ionosphere showed an additional layer of ionisation extending for about 12 miles below the normal lowest level of ionisation (the D-layer). In addition, the rocket data on this occasion showed that the normal ion distribution in the ionosphere above the lowest layer remained apparently undisturbed during the blackout.

Subsequent rocket soundings carried out by the Americans have shown that the additional electron layer below the D-layer is caused by solar x-ray emission in the 1–2 Å range associated with solar flares of above a certain magnitude.

Another means of studying the effect of the Sun on the ionosphere is to observe the region under "no-sun" conditions—in other words, during the three months polar night that occurs in the immediate vicinity of the Poles. The Americans have been operating an IGY station within a quarter of a mile of the South Geographic Pole. Ionospheric observations throughout the polar night of 1957 have produced the surprising result that, despite the prolonged absence of the Sun, the ion concentration above the area remained very high. A diurnal variation continued to be apparent although there was of course no alternation of day and night. This variation is at present being attributed to geomagnetic activity though the precise relationship is not yet clear.

Seismological Activity in America

Work carried out last summer and autumn in the **Andes** by U.S. scientists from the Department of Terrestrial Magnetism of the Carnegie Institution, Washington, has shown that this great mountain chain has roots of quite unsuspected depths. Their work continues in this area and is now



This record from the Isabella, California, extensometer shows the 12-hour tidal period for December 4, 1957, the date of the large (magnitude 8.5) Mongolian earthquake, $\triangle = 10{,}000$ km. The strains from the earthquake are superimposed on the trace of the semi-diurnal earth-tide. The letters *G* and *R* on the record refer to Love- and Rayleigh-type seismic waves respectively. These waves have travelled along the outermost portion of the Earth's mantle, just beneath the relatively thin crust (10–50 km. thick), from their earthquake source to the instrument site. Such waves travel outward from the disturbance in all directions, commonly circling the Earth a number of times.

Love waves travelling the shortest arc to the instrument (10,500 km.) are designated G_1. Love waves travelling the passages have correspondingly higher subscripts. Time of origin of the earthquake represented by *O*; *P* and *S* show the passages of the short-arc waves are shown by G_2 and R_2; and of the long-arc waves by G_4 and R_4, and subsequent longest arc (29,500 km.) are designated G_5 and Rayleigh waves travelling the longest arc are designated R_5. The second first arrival of compressional and shear waves respectively, which have penetrated the mantle to considerable depth.

each 25 metres long and with a sensitivity sufficient to record accurately a strain increment of 1/10 in. in 2000 miles.

The Isabella instrument is of the same design as the South American extensometers having two fused-quartz tubes

(Record reproduced from IGY Bulletin, *National Academy of Sciences, U.S.A.)*

directed to gaining a better understanding of the crustal structure of the range.

The Lamont Geological Observatory has nearly completed the installation of ten special long-period seismographs for operation in two chains, one from Hawaii to Fiji in the Pacific, the other running from Bermuda to the Antarctic. These instruments are sensitive to surface waves with 400-sec. periods. These are only generated by the very largest earthquakes, and wave-lengths of this order are so long that they penetrate deeply into the Earth's interior and may sometimes even set the whole earth vibrating. While engaged on work with this type of seismograph, workers at Lamont have recently discovered certain **intermediate-length waves**. These have a period of about 100 sec. and have only previously been observed in the crust. The Lamont work has identified them now in the mantle (the layer situated immediately below the outer, crustal layer of the Earth). Being shorter, they permit better resolution of structural details than the deeply penetrating 400-sec. waves. It is therefore hoped that their study will prove especially valuable in determining the distribution of the materials of which the Earth's interior is formed.

Earth-strain measurements are to be carried out in Peru and Chile, using newly installed fused-quartz extensometers, a type of instrument developed since the war at the California Institute of Technology. In contrast to the standard seismograph which measures the passage of elastic waves through the ground, the extensometer or strain-seismograph, measures the differential motion between two nearby points—at the ends of the instrument. The change of length (which may be either an increase or a decrease, stretch or squeeze) divided by the original length gives the change in strain. It is expected that the operation of the fused-quartz rod in the tunnels in which the South American instruments are installed will give an accuracy of one part in 10^9.

The extensometer provides three kinds of information. It measures (1) secular (long-range) strain changes; (2) diurnal or tidal strains produced in the Earth's crust by the gravitational action of the Sun and Moon (*See* IGY Notes, DISCOVERY, April 1957); and (3) ultra-long-period seismic waves, including "free vibrations" of the Earth that may be produced by earthquakes.

(1) Measurements of secular strains might conceivably provide a basis for an earthquake prediction service. This is still a long way off. For the moment the object is to record the value and accumulation of secular strains along the Andes at as many stations as practicable in the hope that over a period the strain pattern and habit of the region may be established. The kind of period envisaged for the completion of this programme may well run into several centuries.

(3) Measurements of tidal strain provide information on the elastic and plastic properties of the outermost layer of the Earth. The long-period waves yield information concerning the mantle and core as well as the mechanism by which earthquakes are produced.

One of the new extensometers is situated at San Cristobal, near Santiago, Chile, and is operated by the University of Chile; the other is installed at Chosica, outside Lima in Peru, and is supervised by the Peruvian IGY Committee. The "control" instrument which has been in use for the past ten years, is at Isabella, California. See graph.

Gas Denser; Micrometeorites Softer

In a discussion of the inferences to be drawn about the density of the upper atmosphere from *Sputnik* observations, two Soviet scientists, V. Krasovsky and D. Okhotsimsky, writing in *Pravda* recently, conclude that at orbital heights the concentration of gas is greater and the density of micrometeorites considerably less than had previously been supposed.

"In the light of the latest information", they deduce that the majority of micrometeorites are not solid particles of stone or metal but more resemble flakes of snow or soot and have a density that is only a fraction that of water. Those that are visible to the naked eye (as "shooting stars" upon impact with the Earth's atmosphere) would weigh about a gramme and have a diameter of several centimetres and might be travelling at as much as 5 miles per second.

On the subject of gas density at the fringes of the atmosphere, they point out that the braking effect of the *Sputniks* has proved substantially greater than could be expected on the basis of information hitherto available about the distribution of densities above the medium latitudes. The actual values for atmospheric densities at perigee in each of the *Sputnik* orbits are higher than those obtained by any of the other methods previously used to calculate atmospheric density.

Polar Medals for Eighteen Australians

The Minister for External Affairs, Mr R. G. Casey, has announced that Her Majesty Queen Elizabeth had approved the award of the Polar Medal to eighteen members of the 1956–7 Australian Antarctic Research Expedition.

Those honoured are: Mr G. L. Abbs, radio operator; Mr P. N. Albion, radio telegraphist; Mr W. G. Bewsher, a schoolteacher who was the officer-in-charge of the 1956 expedition; Mr J. S. Hunt, biologist; Mr M. Y. Christensen, weather observer; Sgt N. M. Cooper, RAEME; Dr D. A. Dowie, medical officer; Mr S. L. Kirby, surveyor; Mr L. G. Gardner, diesel fitter, Mr J. A. Hollingshead, PMG technician; Mr R. M. Jacklyn, physicist; Sgt R. Johansen, RAAF airframe fitter and official photographer for the 1956

expedition; Mr N. T. Lied, radio officer; Mr J. W. P. McCarthy, weather officer; Mr P. M. McGregor, geophysicist; Mr J. A. MacKenzie, cook; Mr J. A. Seaton, of Qantas; and Sgt G. J. Sundberg, RAAF engine fitter.

Sputnik III's Instruments

The third Russian *Sputnik*, launched on May 15, and expected to be up for more than a year, carries a far more impressive payload of experiments than its predecessors, either Russian or American. Twelve studies are being made from it, as follows: measurements of the pressure and composition of the atmosphere; the concentration of positive ions; the magnitudes of the electric charge of the *Sputnik* and the tension of the Earth's electrostatic field; the intensity of the Earth's magnetic field; the intensity of the Sun's corpuscular radiation; the composition and variation of primary cosmic radiation; the distribution of photons and of heavy nuclei in cosmic rays; micrometeorite impacts; measurement of temperature within the *Sputnik* and on its outside surface.

Both chemical and solar batteries are carried. A programming device controls the flow of data to and through the telemetry channels. In contrast with the two previous *Sputniks*, only one tracking-beacon is used, operating on 20·005 Mc/s. The effect of these various changes is expected to make better use of the available power and therefore to lengthen the radio life of the satellite; this also means the effective duration of the experiments. Means of regulating the thermal régime within the satellite have also been incorporated so that the instruments do not suffer from extravagant variations in temperature. Gross overheating may have been the cause of the premature failure of the transmitting system in *Sputnik II*.

The launching of *Sputnik III* in fact placed a total of five objects in orbit—the instrumented nose-cone, the rocket-case, a probe carried on the rocket's nose, and the sheath shielding the nose-cone which was split in two at separation. Four objects (all but the nose-probe) were observed visually by an American Moonwatch team within a few days of launching when the various objects were orbiting in close proximity of each other. Rocket and satellite are very bright objects; it is not expected that the other three pieces will be seen again.

Skylark Yields a Bonus

Skylark, Britain's high-altitude research rocket, has achieved a bonus on its very first scheduled IGY research flight, from Woomera, on April 17.

This round carried three IGY experiments, the principal being the grenade experiment of University College for studying air temperature, wind-speed and direction in the form of spot-readings from about 70,000 ft. to the top of the rocket's trajectory (in this case about 120 km. or about 400,000 ft.).

The last grenade to fire on the night of April 17 went off at about 120 km. high. When the photographs of this explosion were studied, a curious thing was found. Instead of the pinpoint of light, there was a glow that covered quite a considerable area. It was too late in the evening for this to be due to reflected sunlight; the luminescence could only be accounted for by a photochemical reaction between the incompletely combusted material of the TNT charge and the constituents of the rarefied atmosphere at this height. It is known that from about 100 km. for some distance upwards, oxygen undergoes a transition from a predominantly molecular form to a predominantly atomic form. It is thought that the glow detected from Woomera at about 120 km. was largely caused by a nitric oxide reaction between atmosphere and grenade material. The last grenade but one (this went off at about 95 km. up) showed nothing of the kind. Nor has there been any indication that any of the recent American grenade experiments from *Aerobee* rockets have produced a similar luminescence, presumably because they have not occurred so high.

The immediate value of this event is that it is much easier to observe a luminous patch which persists in the sky for some time than the fleeting flash of an explosion. It should therefore make the tracking of winds at very great altitudes easier. It is hoped that more will be learnt of the altitudes at which this reaction may take place and of high-level winds also from subsequent grenade experiments fired from *Skylark*; several of these are scheduled for this summer. At present a closer study of the reaction itself is not envisaged. This could only be done by spectrographic means from the ground and presents very considerable technical difficulties.

Antarctic Weather Turned Upside Down

The Antarctic's ice-balance is maintained by intrusions of warm air masses into the central ice-cap region and not, as hitherto supposed, by a strong high-altitude cyclone more or less permanently situated above the region.

There is no insuperable wind barrier round the continent, as thought hitherto; Antarctic weather therefore plays an active part in the atmospheric circulation of the Southern Hemisphere.

Though the Antarctic ice is receding, it is not doing so as fast as the glaciation in some other parts of the world.

The ionospheric pattern above Antarctica is proving substantially different from that previously evolved on a basis of general inference. The zone of maximum ionospheric disturbance in East Antarctica lies over the ocean, considerably north of the coastline, for instance.

These general conclusions have been drawn by Russian scientists on a basis of the work done by the Soviet Antarctic expedition so far. Some of this material was communicated to other IGY scientists at the recent Antarctic Symposium held in New Zealand.

Dr Oskar Frichak, the leader of last season's team of aerologists, gave an account of a system of six stable high-pressure tongues detected by the Russians. These extend northwards in association with those parts of Antarctica that jut out from the main continental mass. These tongues block the movement of cyclones over the adjoining seas, so trapping them in relatively stable positions. The six cyclone zones that lie between the pressure ridges are: over the Weddell Sea, off the eastern section of Queen Maud Land, over the Mackenzie Sea, off Wilkes and King George V Land, and over the Ross Sea. Such aerial reconnaissance as has so far been carried out confirms that the cyclone regions round the coast have a substantial effect on the location of the coastal ice-belt.

Observation conducted in the interior, last year, "definitely refute" the hypothesis of a stable high-altitude cyclone which feeds the central ice-cap. There seems instead to be a very stable high-altitude *anti-cyclone* and the snow which serves to perpetuate the glaciation comes from cyclones which periodically intrude into a rim zone, 300 to 400 miles wide, round the area.

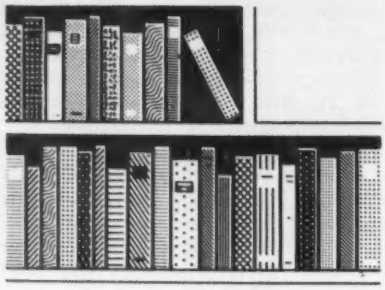
Ridges of the Antarctic anti-cyclones may join those in subtropical regions and so inhibit the zonal circulation. This may well account for the observation that atmospheric circulation in the Southern Hemisphere does not appear typical.

The world's low-temperature record has again been broken by met. observations in the Antarctic, and it is expected to be reduced again before this winter season is out.

First Russian "Meteorological" Rocket Firings in Polar Regions

A total of ten of these smaller rockets were fired during the last six months from the polar regions. Six of these went off from Heuss Island observatory in the Arctic (80° 37′ N, 58° 3′ E). The first was launched on November 4, 1957, and the sixth on February 18.

The first of four rocket launchings by the Russians in Antarctica took place from the deck of *Ob* in the Davis Sea on the last day of last year, December 31.



THE BOOKSHELF

On July 1, 1858, Charles Darwin and Alfred Wallace read a joint paper to the Linnean Society in London, having as title: "On the tendencies of species to form varieties; and on the perpetuation of varieties and species by natural means of selection." The centenary of this unique event in the history of biological thought will be widely celebrated as no aspect of pure or applied biology was unaffected by Darwin. We commemorate it this month by devoting the whole of BOOKSHELF to reviews of biological books.

The Evolution of Living Things

By H. Graham Cannon, F.R.S. (*Manchester University Press, 1958, ix+186 pp., 12s. 6d. net*)

This book is an account of the theories of evolution inherent in Darwinism, Mendelism, and Lamarckism, special attention being paid to Lamarck's ideas. Prof. Cannon rightly points out that Lamarck's theory of evolution did not confine itself to the idea that "everything acquired or changed during an individual's lifetime is preserved by heredity and transmitted to that individual's progeny", but that there were other postulates, notably that "the production of a new organ in an animal body results from a new need which continues to make itself felt, and from a new movement that this need brings about and maintains". He also points out that much of the ridicule heaped upon Lamarck's views in this country arose from the translation of "besoin" as something *wanted* instead of as something *needed*, thus making ridiculous the concept of purposive evolution.

The book is developed historically, a common and useful approach. But such an approach often leads to difficulties of interpretation in another age, in which there is another environment of thought. Two aspects of this environment concern us. Firstly, there was then an almost universal belief in special creation, so that to present a *doctrine* of evolution caused uproar and condemnation. Today, discussion hinges rather upon the *mechanism* of evolution and whether natural selection, or the acquisition of characters according to their need, or some other mechanism is involved. This problem can be solved only by experimental methods.

In the second place, Lamarck and Darwin studied and wrote against the scientific background of their day. Increased knowledge shows some of their factual statements to be untrue or incomplete. It is the stimulus of the new ideas which such men have provided that makes them great and we should take note of this rather than criticise the minutiae of their work.

The viewpoint taken in this book is that the evidence dealt with leads "to the conception of some guiding force within the organism which controls and guides its evolution, not by haphazard changes but by selected modifications". Because of this there is a bias against theories contrary to those of Lamarck—not that one can quarrel with this when one remembers the bias too often shown by those who have depreciated Lamarckism. Even though it is pointed out that there is more to inheritance than the genetic make-up of the organism, the exciting possibilities of such an approach are neglected for arguments for and against the theories of evolution under consideration, arguments that have been used many times in the past.

It is perhaps unfortunate that this book should be addressed, as the author states in his Preface, to the "ordinary man, whether layman or scientist", because a good background of biology is essential for a proper appreciation and interpretation of the material dealt with. Because it is written in rather general terms it sometimes reads as though statements of fact are being made where the matter is rather one of opinion. An outstanding example of this is the statement that "genes demand the parallel bars of chromosome behaviour for their gymnastics" and that "Mendelian inheritance can go back only as far as the origin of chromosomes", from which it is concluded that genes are lacking in bacteria and viruses. Modern work has produced mechanisms in such organisms but also that these are fundamentally the same as those found in other living things. An example of this is the work of Hartman on the linear arrangement of genetic loci in the bacterium *Salmonella typhimurium*.

N. J. B. PLOMLEY

Fossil Men, A Textbook of Human Palaeontology

By Marcellin Boule and Henri V. Vallois. Translated from the fifth French edition of "Les Hommes fossiles" by Michael Bullock (*London, Thames and Hudson, 535 pp., 298 illustrations, 84s.*)

The first English translation of this well-known and valued work should be an essential piece of equipment for all who have an interest in the physical evolution of man, for revised editions of the original have been, since the war, the only textbook in any language with any pretensions to being complete and up to date. The classical works of Keith, Elliot Smith, Abel, and Obermaier, to name a few, date up to the 1930's only. Much has happened in this field since then, both in terms of newly discovered material and of recent interpretation. Even more than these, the second edition of "Boule" was very out of date by the end of the war and a third had been undertaken when the original author died. It was completed and published in 1946 by Prof. H. V. Vallois, his successor at the Muséum d'Histoire Naturelle and at the Institut de Paléontologie Humaine.

The finest days of prehistory and palaeoanthropology ended when it became impossible for one man to be simultaneously among the leaders of Pleistocene geology, human palaeontology, and Palaeolithic archaeology. Boule had been one of these leaders. Today Vallois is obliged to divide the labour between his versatile colleague at the Institut (Prof. Vaufrey), and others, with regard to the geological and archaeological aspects of the earliest history of man. It might be supposed that he would have been equally supported in the monumental and pious task of bringing and keeping "Fossil Men" up to date. Unfortunately this has not been so, with the result that the geological and archaeological sections of the book, though here and there patched up, lag woefully behind the extremely high standards of detail and modernity shown on the palaeontological side. So much of Vallois has by now necessarily gone into the "joint authorship" that the question arises whether it would not be better either to produce a full textbook by him on the palaeontological material alone, or to enlarge evenly and amend "Boule" all round, in collaboration with an author or authors of equal competence in the other fields. The latter alternative would perhaps put the joint work entirely beyond the economic reach of most students, as it nearly is already.

This is the main criticism. The principal section is as up to date as any synthetic work of its size can hope to be in these days of breathless advance and ever-expanding literature. Practically only the very latest discoveries, such as Pei's *Gigantopithecus* jaw and the presumed artifacts of *Australopithecus* at Sterkfontein, announced this year, receive no mention. Only one omission of a date early enough for inclusion (1949) has been noticed. This is the date of Hürzeler's finely illustrated study of *Oreopithecus bambolii*, a Miocene monkey.

The tooth on the right of Fig. 30 (p. 45) is, in the opinion of this reviewer, certainly not of *Tichorhinus*, as stated, but perhaps of *Dicerorhinus hemitoechus*. For the rest, the history and the varied opinions of scholars past and present on this growing body of material are fully and fairly presented from a balanced point of view. Where so much remains unknown (and unknowable, with any certainty, until more plentiful and more complete specimens are available) it is not surprising that (frequently) wild hypotheses abound and considered views, even among the best informed, often differ radically. This is, in fact, part of the fascination of the subject to a newcomer; when experts differ, even the most ill-informed amateur feels tempted to "have a go" at theorising. The authors' repeated insistence that palaeontological, plus stratigraphical evidences alone entitle us to take up a firm stand on the details of human evolution is timely, and not only for amateurs; some of the greatest experts have been prone to rely too exclusively on morphology, in disregard of chronological considerations.

The translation is clear and only now and then betrays its origin in a rotundity of expression not quite Anglo-Saxon and occasional slips in English technical usage, as contrasted with French. There are a few but not, generally, serious misprints—inevitable in the first printing of any large book. The worst noticed was "Oreopsis" for "Oreopithecus" in the Index.

There is a comprehensive historical Introduction to the English edition by Dr K. P. Oakley.

I. W. CORNWALL

Biological Aspects of Cancer

By Julian Huxley (*Allen & Unwin, 1958, 156 pp., 16s.*)

In 1955 the author was invited to deliver the first A. P. Sloan Lecture at the Sloan-Kettering Foundation. The lecture material was expanded into two reviews, published in consecutive issues of *Biological Reviews*, and these reviews with considerable new material added, make up the present book. Books about cancer usually fall into two main categories—the semi-popular which aims either to instruct the general public on the medical aspects or to present an outline of current research, and the encyclopaedic which strive to encompass the whole field for the benefit of specialists. In the latter category, too, come the many reviews, written by specialists for specialists.

This survey comes into neither category but was written for biologists in order that biological science should profit "from the incorporation of the cancer problem in its purview".

The first seventy pages are occupied by a consideration of the comparative distribution of neoplasms and with tumour genetics. Carcinogenic, and other viruses occupy the next twenty pages, and the final section is devoted to tumours and epigenetics (the analytical study of development).

The author has read extensively the more recent literature; more than 500 papers and books are indexed and the great majority of these were published since 1950. However, the advantages of a general survey of this kind, from one who has never worked, as he says, in this or indeed in any medical subject, tend to be outweighed by the uncritical approach. For example, he quotes some very recent work on the chemotherapy of transplantable rat tumours with hydrogen peroxide, results which other workers have subsequently failed to confirm; conflicting results in the tumour virus field are set down in successive pages. This unbalance reflects, to some extent, the transition from lecture to book. It is not serious for those engaged in cancer research but it might mislead other biologists. In this respect the first section of the book—the comparative distribution of neoplasms and tumour genetics—is better than the other two. One has the impression that the author's real interest lies here. More than twenty topics are suggested for future research; yet another good reason for recommending the book to biologists *in* cancer research! The author is happier, too, with biological rather than with chemical nomenclature. There are a number of mistakes of this kind, and an old friend, the prostrate tumour, appears on p. 110.

Sir Julian says that "the preparation of these two reviews involved me in more hard labour than anything I have attempted since I took my Final Honours examination in Zoology at Oxford. . . ." It is, indeed, an excellent thing to have distinguished scientists who, freed of teaching, administration and the like, have the patience and the ability to devote themselves to surveys of this kind. The biological aspects of cancer have been outlined in this book; the landmarks have been noted. May we now ask the author to proceed to possess the land and, further, to plough it.

R. J. C. HARRIS

Insect Flight

By J. W. S. Pringle, Cambridge Monographs on Experimental Biology, No. 9 (*Cambridge University Press, 1957, viii+ 132 pp., 15s.*)

Behind the wings of two-winged flies (Diptera) there are a pair of club-shaped organs, the halteres, which vibrate rapidly in flight. These halteres are sense-organs which provide the fly with information about any departure from a straight course. If the body of the fly is rotated, fluctuating gyroscopic couples are set up at the base of the halteres, where they are detected by special sensory cells. In response to stimulation of these cells, reflex twisting movements of the wing are made which restore the fly to its original course. A fly cannot fly if the halteres are removed. But if a piece of cotton or feather is stuck to the abdomen of such a fly, so as to project backwards like the feathers on the back of a dart, the insect can again fly, albeit somewhat clumsily. The fly now has "weathercock" stability, and no longer requires sensory information from the halteres to maintain a straight course.

This is an example of the kind of information which has been gained by looking at flying insects as if they were machines. The subject is a fascinating one, and Pringle's book is the first general account of it to be fully satisfactory, being at the same time comprehensive, comprehensible, and technically accurate.

The book is not an easy one to read, but this is not the author's fault. Many of the adaptations described are highly complex. For example, eight pages and two diagrams are devoted to explaining the mechanism of the wing joint in Diptera, whereby the wing is automatically twisted to the correct angle. But many authors could have written at twice this length without making the matter clear. To follow Pringle's account requires effort, but the effort is worth making. Once understood, the joint is seen to be one of great elegance and ingenuity.

In fact, the main merit of this book is that it is intellectually satisfying, and should give real enjoyment to biologists willing to think in engineering terms, and to engineers and physicists wise enough to know that they can still learn something from biologists. To encourage the latter type of reader, it is worth pointing out that since Pringle in 1948 elucidated the mechanism of the Dipteran halteres, an instrument working on the same principles, the Gyrotron, has been developed to measure angular velocities.

J. MAYNARD-SMITH

Handbook on the Care and Management of Laboratory Animals, 2nd Edn.

Edited by A. N. Worden and W. Lane-Petter (*The Universities Federation for Animal Welfare, 1957, xix+951 pp., £3 10s.*)

In this month of the Darwin centenary, much will be said about Darwin as an evolutionist. But he was also a pioneer, and himself an active participant, in the struggle for a humane attitude towards experimental animals. The struggle is still being waged: today, its combined Bible and Baedeker is the UFAW (Universities Federation for Animal Welfare) "Handbook on the Care and Management of Laboratory Animals".

The first edition, published in 1947, weighed 1½ lb. The second edition weighs over 4 lb. Many will wonder whether they can afford to lay out £3 10*s.* on this book. In fact they cannot afford not to: humanity apart, the initial cost will be rapidly repaid in animal house economy.

The first fifth deals with the general considerations which govern the humane and efficient management of animals in laboratories, including chapters on breeding methods, animal house equipment, nutrition, disease, and anaesthesia. Even the sharpening of hypodermic needles is dealt with. The outstanding conclusion is the extent to which the demands of humanity and of efficiency coincide. As a mouse-breeder, I was particularly impressed by the chapters on the genetic and economic aspects of breeding, by Drs Falconer and Carter respectively. And while it is impossible for any two animal breeders to agree on the ideal design of cage, Dr Lane-Petter has produced an admirably fair-minded survey of the bewildering variety of designs in use.

The chapter on the Animal Technician draws attention to a vital problem: the acute shortage of suitable personnel for the care and management of laboratory animals. Here and elsewhere in the book there are many references to the necessity of raising the status of the animal technician, but nowhere is it pointed out that the most effective way of raising his status is to raise his salary. The job is a responsible one, requiring aptitude, skill, knowledge, and a high degree of reliability. Yet it is paid as unskilled labour! Most experimental biologists would agree that a substantial increase in the wages of animal technicians would do more to raise the standards of animal management in this country than any other single measure.

The remaining four-fifths of the book deals with the various species of laboratory animals individually, including unconventional laboratory animals such as the horse, paramecium, fish, porcupine, earthworm, sheep, prairie mole, and fox. There are even brief sections on such bizarre species as the vampire bat, marsupial mouse, and tsetse fly (mammal-lovers will read with regret the recommendation that the latter species should be fed on the flanks and abdomen of sheep!). The information provided in this part of the book is fascinating, even for those who may never need to apply it in practice.

Among the more humdrum laboratory animals, I regret only that the chapter on the mouse does not deal with the reproductive biology of the animal—copulation plug and vaginal smear techniques, methods of artificially inducing ovulation and superovulation, artificial insemination, and so on. Such information lies well within the scope of the book (it is provided to a greater or less degree for other species) and would be of great value to those who work on mice.

One aspect of animal welfare is neglected in this book, as elsewhere—the psychological. For animals as for

humans, happiness is an essential prerequisite of health; and a bored animal is not a happy one. The problem, briefly discussed by Major Hume in his opening chapter, is barely mentioned again.

For instance, on several occasions reference is made to the well-known observation that wild rodents often fail to breed in captivity unless provided with an exercise wheel. How confident can one feel, in the absence of any evidence to the contrary, that "difficult" strains of laboratory rats and mice would not also be helped by more opportunities for exercise? Yet Dr Lane-Petter writes:

> "The furnishing of rat and mouse cages with exercise wheels and other toys seems equally pointless and almost as objectionable (that is, as complicated cage designs). Anyone who has . . . heard the commotion in a mouse house at night time will realise that most cages can provide simple and satisfying diversions to beguile the rodents' leisure hours."

I invite the reader to read the last sentence aloud, substituting "prison" for "mouse house", "cells" for "cages", and "inmates" for "rodents".

With monkeys, the problem becomes acute. Yet toys for monkeys are nowhere discussed. The single "constructive" suggestion comes from Dr Luck, who mentions that he refrained from ridding his vervet monkeys of their small, transparent, and very faithful lice, in the hope that they would provide a "medium of occupational therapy"!

Since research on many of the subjects covered is expanding very rapidly, I hope that a third edition is even now in course of preparation. A. MCLAREN

Flora of the British Isles Illustrations

(*I. Pteridophyta* to Papilionaceae)
By Sybil Roles (*London, Cambridge University Press, 1957, 144 pp., 25s.*)

To illustrate at a reasonable price the 2000-odd species recognised by Clapham, Tutin, and Warburg is no mean task. Miss Roles anticipates that it will require four demi-quarto volumes, the first of which, extending from the Pteridophyta to the Papilionaceae inclusive, is now available at a price of 25*s*. One remembers, however, that Fitch and Smith managed to compact illustrations of 1315 species into one volume of much smaller dimensions and one is therefore prompted to compare the two works. It soon becomes clear that Miss Roles has been far more liberal with her illustrations, but hard upon this comes the impression that many of these drawings are superfluous. Is it necessary to illustrate, for more than 90% of the species, so variable a feature as the habit of the plant?—especially with drawings which, as in many cases, are so confused that it is difficult to distinguish between the leaves and inflorescences or flowers. The drawings of the *Fumaria* spp. and *Vicia* spp. are extreme examples of such profitless work, to which much space and labour are devoted.

The more advanced student, though grateful for pictorial descriptions of the species segregated since the work of Butcher and Strudwick, will find more to irritate him. The general level of the drawing is somewhat inferior to that of Fitch and Smith and diagnostic features are often not illustrated. The scale of the drawing is given but similar species are each often drawn to a different scale. Furthermore the scales rarely bear a simple relationship to one another. The four-to-a-page pattern is rigidly adhered to with the result that similar species are sometimes to be found on the reverse sides of a sheet. The advanced student may look at his money more than once before embarking upon the purchase of this series of volumes, but for the beginner the book is of undoubted value. D. J. BOATMAN

Collecting, Preserving and Studying Insects

By Harold Oldroyd (*London, Hutchinson, 1958, 327 pp., 25s.*)

A very large proportion of small boys collect insects, usually butterflies and moths. It is a healthy occupation, especially for a solitary child, based partly on atavistic food-collecting instincts and partly on the magpie-like acquisitiveness which starts any collection, be it of stamps, coins or even railway-engine numbers. As the young butterfly-collector grows up, he usually finds both these urges intellectually sterile, so that nine out of ten insect-collections decay slowly in lumber-rooms. In this way, many potentially serious naturalists never realise the interest of biology and the world loses a number of professional entomologists.

Mr Oldroyd's book should prevent some of this wastage. As he remarks in the Introduction, "The real value of an insect collection . . . is not to admire it, but to use it to study living insects." Part of the book, therefore, introduces a lay reader to the scientific aspects of entomology, the technical jargon being explained and reduced to a minimum. The emphasis is very much on systematic entomology, which is perhaps more within the grasp of an amateur; but something might have been said about insect internal anatomy and physiology, if only to indicate these fields of study. Most of the book, however, is full of very practical instructions for collectors, illustrated in the clearest possible way by photographs and original drawings. These hints will be especially valued by the solitary collector, who is without help from an experienced naturalist.

From what has been said, it is scarcely necessary to add that this book would make an excellent birthday present for an intelligent youth. J. R. BUSVINE

Brief Notes

Three booklets published by FAO, "The Report of the Working Party on Crop and Livestock Insurance" (2*s*. 6*d*.), "The Report of the Nutrition Committee for South and East Asia" (2*s*. 6*d*.), and the "Select Bibliography on Co-operation" (2*s*. 6*d*.), have also been released by H.M.S.O. The "Report on Crop and Livestock Insurance" discusses the need for such insurance in countries of Asia and the Far East, together with the advantages and difficulties involved, as well as the kind of insurance suited for underdeveloped countries. The "Report of the Nutrition Committee" considers the major nutrition problems of Japan. The "Select Bibliography" provides a list of publications on co-operation given, in addition to particulars on publishers, length, and price, and brief summary of the contents of books which they believe should be in any good co-operative library. The U.S. Government Printing Office has prepared a "List of Available Publications of the United States Department of Agriculture" (45 cents). The list was compiled by Eleanor W. Clay, and may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

The "Wildlife Management Bulletin" and "Migratory Birds Convention Act and Migratory Bird Regulations" may be obtained from the Canadian Wildlife Service, Department of Northern Affairs and National Resources, Ottawa.

The Ninth Annual Report of the Commonwealth Scientific and Industrial Research Organization for the year ending June 30, 1957, has recently been published.

The Report is a long and technical document covering the wide varieties of scientific researches being undertaken by CSIRO in such diverse fields as entomology, animal health, plant industry, forest products, industrial chemistry, and radiophysics. It outlines work on hundreds of projects of importance to Australia's primary and secondary industries.

Work on rain-making, mineral deficiencies of soils, sheep and wool research, prevention of evaporation, and many other major projects are dealt with. In addition, it contains valuable information on: North Queensland coal, improved pastures in the Northern Territory, roasting copper concentrates, prevention of moss growth in concrete races, and increasing fleece weights.

LETTERS TO THE EDITOR

The Fascination of Numbers

Sir:

The article published by W. Reichmann under this title (DISCOVERY, January 1958, p. 17) is intended to stimulate the interest of laymen in arithmetical problems. Some of his examples are well chosen, others are not. One example is introduced with the words: "The writer has been fortunate in discovering a hitherto unsuspected basic relation, etc." This seems to me an exaggerated claim. The statement is that all numbers which are not prime, and only these, can be represented by a sum of consecutive even integers or a sum of consecutive odd integers.

Now each integer n, which is not prime, can be written, in at least one way, often in many ways, as a product of integers

$$n=pq. \tag{1}$$

Let us assume $q \leq p$ and distinguish the cases q even and q odd. To show this to the eye, two vertical lines are introduced and (1) written in this way:

$$(2)\begin{cases} q \text{ even:} \\ \quad n=p+p+\ldots+p|+|p+p+\ldots+p, \\ q \text{ odd:} \\ \quad n=p+p+\ldots+p|+p+|p+p+\ldots+p, \end{cases}$$

the total number of terms in each case being q. This can be obviously rewritten in the form:

$$(3)\begin{cases} q \text{ even:} \\ \quad n=(p-k)+\ldots+(p-3)+(p-1)|+| \\ \qquad (p+1)+(p+3)+\ldots+(p+k), \\ q \text{ odd:} \\ \quad n=(p-k)+\ldots+(p-4)+(p-2) \\ \qquad |+p+|(p+2)+(p+4)+\ldots+(p+k, \end{cases}$$

where $k=q-1$.

But (3) is just the "representation oy a series", as the author calls it.

I cannot believe that this trivial modification of the definition (1) of a non-prime number can be of much use in the investigation of primes.

MAX BORN

Bad Pyrmont and Edinburgh.

International Geophysical Year

Sir:

You may be interested to learn that in your November issue (1957, p. 485, end of second column and beginning of third column) you made a statement which at first sight appears to be correct, but which is actually fallacious. You thus state: ". . . the flood resulting from the melting of all the world's ice would be twice as high as previously thought . . . as the previous computation . . . of the volume . . . will be . . . 50% short of the mark".

Now according to your article, most of the newly discovered ice is below sea-level, and the original estimate of the volume of the Antarctic ice appears to assume that the bottom of the ice rests on land which is just above sea-level. In your statement you did not take into account the fact that ice, on melting, contracts by 10%. On melting, therefore, the ice under sea-level would be converted into water of 10% less volume, which would approximately counteract the increased volume of ice originally assumed to be land.

The statement in the previous paragraph may be calculated to be true using the estimated values of 14 million sq. km. for the area of Antarctica, and 1·8 km. as the average height of the continent (*Encyclopaedia Britannica*). In this case the volume of ice above sea-level, assuming no land at all, would be 25 million km.^{3}. If, as now appears possible according to your article, approximately the same amount of ice is under water as above water, this will, on melting contract by 10%, so that the effective volume of Antarctic ice available for flooding will be reduced to 22·5 million km.^{3}. This figure would probably be reduced closer to your figure of 20 million km.^{3} if known land-masses were subtracted. At all events it may be seen that the original calculations of the flooding in the world caused by the melting of the Antarctic ice are a maximum figure.

In view of the latest utterances by certain politicians that it would be possible to melt the polar ice and thus flood the world partly, it is interesting to note that the Arctic ice sheet, on melting, would not affect the level of the oceans at all. This is because the Arctic ice is floating, and a given mass of water will displace the same amount of water whether it is liquid or frozen to ice. (This statement would not hold if ice were of greater density than water.) If this is not clear, it may be verified by simple arithmetic and by an experiment with a piece of ice floating freely in a glass of water.

I trust that the above points may be of interest to you.

SYDNEY BEECH

Chemisches Institut, Universität Saarbrücken.

Earth-minded Astronomers

Sir:

I was interested in the comment by Dr Davidson when reviewing Mr Moore's book (DISCOVERY, 1958, vol. 19, No. 4, p. 170), to the effect that some astronomers have been reluctant to consider spaceflight feasible. This reminds me of the comments of Prof. Simon Newcomb in "Sidelights on Astronomy" (1906), who wrote:

> "The demonstration that no possible combination of known substances, known forms of machinery, known forms of force, can be united in a practicable machine by which men shall fly long distances through the air, seems to the writer as complete as it is possible for the demonstration of any physical fact to be."

These remarks were echoed later by Prof. F. R. Moulton in "Consider the Heavens" (1935), who commenced:

> "It must be stated that there is not the slightest possibility of such a journey. There is not in sight any source of energy that would be a fair start towards that which would be necessary to get us beyond the gravitational control of the Earth."

Prof. Moulton went on to describe many more reasons why spaceflight could never be achieved, and we are brought up to date with the elegant utterance by Dr Richard van der Riet Woolley, F.R.S., the Astronomer Royal, who said, on arriving at London Airport on January 3, 1956, "It's utter bilge. . . ."

It ought to be fairly clear now, even to the most earth-minded of our astronomers, that it is inherently dangerous for scientists to make prophecies outside their field of special knowledge.

L. J. CARTER

British Interplanetary Society, S.W.1.

Grant Patents More Freely

Dear Sir:

In the first paragraph of the leading article about the patent system in your May issue there is a reference to the recruitment of examining staff from which it might be inferred that the Patent Office was making no progress at all. It would be unfortunate if this were to discourage anyone thinking of entering the Patent Office as a career and, I am sure, contrary to the intention of the writer of the article. In fact, during 1957 the Office obtained fifty-eight new Examiners, twenty-five through the ordinary competition, twenty-two through a supplementary competition with a higher age limit, and eleven by transfer from other Government Departments. Further competitions are now taking place, and we hope to welcome some more recruits as a result.

Yours faithfully,

G. GRANT
Comptroller-General

The Patent Office,
25 Southampton Buildings,
London, W.C.2

Television in April

With a programme devoted to pneumoconiosis and bronchitis, the BBC brought to an end its much-criticised series, "Your Life in Their Hands". This last broadcast was rather more strictly scientific than most of its predecessors, for a good deal of the available time was devoted to an explanation of the use of random sampling in the statistical approach to the study of the incidence of disease. Although good on the whole, much of the very limited camera-time available was wasted on useless dramatic build-up, such as close-up shots of plodding feet (the feet of the inquiry investigators), film sequences which merely consumed time.

Now that this series has come to an end, a retrospective survey leaves little doubt that its total contribution as an educative force in medical science has been somewhat indifferent. There has been far too much exhibitionism of morbidity, too much popular (often pointless) over-dramatisation, and too little real biological and medical science. Starting off ambitiously, and appearing at the outset to imply very real promise, the actual realisation fell far short of expectation.

However, in happy contrast, on April 16 the BBC initiated what promises to be a most exciting and brilliant series in commemoration of the centenary of the publication of the famous paper by Darwin and Wallace, in which the bombshell of evolution through natural selection burst upon an incredulous world. Six programmes, under the generic title, "Five Hundred Million Years", have been allocated to this. There will be one a week, and the ultimate subject is the evolution of man. It was announced that they were to be produced by James McCloy, and knowing his professional interest in biology, one could anticipate that here we would have a thorough, a dispassionate, and a comprehensive scientific approach.

With the clear object of breaking-in the viewers to the more technical treatment which of necessity must follow later, the first programme, entitled "Did It Happen?", laid bare first of all the basic evidence for an evolutionary descent. The subject was opened by Dr Freeman, who covered an enormous and interesting range of animals with some compact, admirable film. Unfortunately, our old enemy in science broadcasts turned up again; that is, the use of *unexplained* technical terminology. For instance, it seems to me a deplorable weakness to hear a lecture on evolution *to a lay audience*, with naturally frequent repetition of the word "species", yet not the slightest attempt to explain what species means. And I am quite convinced the lay audience has not the slightest idea of what is implied by this word. This is, of course, but one example. A later speaker used the term "pentadactyl" without explanation; obvious enough to many, but certainly obscure to far many more. Such defections are so easily corrected and they certainly weaken a broadcast if persisted in.

After Dr Freeman, Prof. Medawar took up the thread. He selected as an example of the evolutionary process, the relationship between a wide variety of forelimbs, illustrating his theme with some excellent film, and better still with live animals. This was a very lively and attractive section of the programme.

Dr Swinton then took up the story with the contributions made by palaeontology and soon had us fascinated, as always, with his accounts of fossils. In particular, his concise survey of the evolution of the elephant's trunk was a notable contribution.

To wind up, Dr Newth described the embryological contribution to the unravelling of evolutionary processes.

This whole programme was packed tight from beginning to end with intensely interesting and varied biological information. It was admirably adapted to an intelligent adult audience and was certainly a capital introduction to evolution.

The second programme of the series was given on April 23, with the title, "The Struggle for Survival", and here too a very high standard was reached; indeed, the programme was even better than the first. The scheme was the same as before. A small group of distinguished experts, taking up a continuous thread, and occasionally interrogated by William van Essen. The broadcast began with Dr Harrison Matthews of the London Zoo, who chose marsupials in Australia and the fauna of the Galapagos isles as his subjects. Then followed Sir Solly Zuckerman with an exciting fifteen minutes. Reviewing first the way in which Darwin's ideas had grown upon him, the significance of the enormous prolific multiplicity in nature and its importance to natural selection was emphasised and illustrated with telling film and amusing animated diagram. This section was concluded with some beautifully selected examples, on film, of the fight for survival.

This was certainly a brilliantly lucid and compact exposition of Darwin's views on the mechanism of natural selection. Rarely on television has so comprehensive a content been so elegantly expressed. Elegant essentially because it was so beautifully compact yet delivered in simple non-technical language, without the slightest descent into "popular" science. Veritably a *tour de force*.

The description of the fight for survival was followed with logic by Dr Kettlewell with his story of industrial melanism in moths, so well known now even to the beginner in biology, yet certainly a novelty to the millions who view television. The survival value of camouflage and its operation in connexion with bird attack on the pepper moth was illustrated with some delightful film and one really did get the impression and feeling that here one was actually witnessing the process of natural selection at work. This was very "live" biology at its best.

The broadcast wound up with an impressive tribute to Darwin from Sir Solly Zuckerman. The only criticism one can offer, and it is not a serious one, is that there was perhaps too much film in this programme, although the subject justifies this.

Finally, Patrick Moore's monthly "The Sky at Night" turned out to be rather a failure. Indeed, it is the only really inadequate programme I have seen from Mr Moore, whose numerous past broadcasts have invariably elicited my admiration. In this ambitious attempt, however, a television camera was set up at a modified eyepiece of the small refracting telescope at the Hampstead Observatory and with it direct "live" pictures of the Moon were transmitted. The telescope or the adjustments appeared to be quite inadequate for the purpose, for despite excellent seeing-visibility, the transmission was poor. (At least, the sky was cloudless and visibility was perfect from my window, which is but a few miles from Hampstead.)

It is naturally admitted that such a broadcast is technically difficult, yet the fair justification for criticism lies in the fact that the BBC did actually some years ago produce a far more effective spectacle.

S. TOLANSKY

XII ISFA Congress

An indication of the growing recognition of all aspects of scientific films is this year's XXth Congress of the International Scientific Film Association, which will

take place in Moscow between September 10 and 20. A Festival of Popular Science Films will take place simultaneously.

Films on the topics popularising science and technology are invited; and research films from any field of science or technology. Film-makers should send films for selection to their national representative—for this country, the Scientific Film Association. In addition, films are invited which deal with problems in astronautics, television, in connexion with image intensifiers, the effect of light on cell structure during cinemicrography, and the comparison of results of phase-contrast and interference cinemicrography of living cells.

"Makers of Science No. 1"

Recently, Messrs Macqueen Film Productions have produced a film which is designed to tell the story of Sir Harold Spencer Jones, F.R.S., until lately Her Majesty's Astronomer Royal, and the Royal Greenwich Observatory. This reviewer had the privilege of seeing the film in what may be termed an uncut state. It had been edited and put together with a sound-track but was not in the final form in which it will be shown. Let it be said straight away that the film is much to be commended and the following criticisms must be considered as a form of interim report.

The film begins with some views of Herstmonceux Castle, the new home of the Royal Observatory, and then traces through the history of that great institution which was originally established in order that more precise stellar information might be available to navigators, and which still continues to produce such information with an accuracy which would no doubt surprise earlier Astronomers Royal. Further, the film shows how the Royal Observatory is also responsible for the time standards in this country and how, nowadays, it also carries out much fundamental astronomical research. Sir Harold Spencer Jones appears in the film from time to time and explains what it is all about. Finally, the film goes on to deal in a visual manner with some of the problems which face the astronomer at the present time, and therefore shows something of the never-ending seeking for knowledge which is the driving force behind the scientist.

It was not clear, however, after seeing the film, what kind of audience the producers had had in mind. As it stood, the film was too long (it lasted for 40 minutes) and it attempted to deal with too much detail. Again technical terms were not always explained; of course, the solution of this problem depends to a large extent on the audience for which a film is made. Nevertheless, the film appeared to fall between two stools. As a history of the Royal Observatory it was good, and with a little judicious editing and a little more equally judicious shooting it could be excellent. It cannot be considered a biography of Sir Harold, for it does not deal with certain work for which he is well known among his colleagues. Lastly, the vision which it gives of the problems which face present-day astronomy brings together too many matters for a general audience; at least too many matters to be dealt with after we have traced through the history of the Observatory and been concerned with something of the life of Sir Harold. Indeed, one is tempted to suggest that there is enough material in this film (with what must already remain in the cutting-room) to make three very good productions.

With these criticisms in mind, let it be said that the director has used his imagination and produced at all times material which is worth seeing. It is understood that some serious cutting of the film is now being undertaken and it is this reviewer's belief that we shall have in due course a film which will have been well worth making and which will be equally well worth seeing.

Messrs Macqueen Film Productions have envisaged this film partly as an experiment and partly as a forerunner of a series of films dealing with the work of well-known scientists. This aim is much to be praised. While science is international, while the scientist himself works not alone but in collaboration with his colleagues, both here and abroad, there is a tendency for us to neglect the work of our own people and to be for ever praising and paying attention to the work of those who live elsewhere. Moreover, in these days of propaganda run on national lines and with government subventions, it is important that those contributions which the British scientific community has made in the past, and is still making, be brought to the notice of the world. Although this film, in its present state, cannot then be given unqualified approval, it is a grand conception and it is very much to be hoped that the desire of the producers to make a series of such films will receive the co-operation and support which it so richly deserves.

C. A. RONAN

International Conference on Research Film

I.S.F.A., Paris, April 28–29

The very active president, Dr Robineaux, and his staff provided a full programme for the crowded meetings. A typical Parisian lunch united us for the only social function, the rest of the time we were hard at work viewing and discussing new techniques and reports. I wish I could say that the films and papers submitted were of equal merit or weight. As this is hardly ever possible in international conferences (with so many factors and sensibilities to consider), we were grateful for so much excellence offered to us in the event. The British film, made by K. Moreman at the Chester Beattie Cancer Research Institute, *Analysis of Reactions between Antibodies and Living Cells* was technically by far the best of the batch offered, using the novel and striking technique of interference microscopy. The important discussion showed that the East German users of it (in a fine film on Living Blood Cells) accepted the British system as superior. The films were weighted on the subject of cytological research, but this fact offered good opportunities for comparison even to the non-specialist: Of very great value and clarity in realisation were two films from Heidelberg (Prof. Lettré on Human and Animal Tumours in Vitro, and Behaviour of the Nucleole) and The Culture of Organs in Vitro from the Collège de France (Prof. E. Wolff).

A notable contribution and exception to the medical bias of the conference was made by Dr G. Wolf of the Göttingen Institute. These were three short research film records from the Cine-Encyclopaedia on *Arenicola marina* (Waterworm), *Aphrodite acuteata* (Sea Mouse), and *Choloepus didactylus* (Climbing Sloth), three first-rate studies of animal behaviour. The same institute later supplied some short outstanding records of Venezuelan Fire-Boring, Bow Making by the same tribe, the Waika (doomed to extinction by encroaching Western technology), and an exact social study of a Shaamba Arab family, preparing a meal for visitors. No film could approach in beauty and finish of detail the Australian (N. Monkman's) *Nests in the Sun*, a record of bird and turtle life on the Great Barrier Reef of North Australia. Such films as these amply make up for some surprisingly sketchy entries and the long shop-talks of the cytologists.

These gatherings are indeed necessary and welcome, for each annual meeting is so stimulating that it may be necessary in future conventions to form smaller groups to cope with the specialisms growing at a formidable rate. Our next hosts at Utrecht have noted my appeal for including, even *stressing*, social research—a field in which Dutch film research has been prominent for years. It is clear that the Paris meeting offered again delightful, if all too brief, reunions with friends and colleagues.

J. HORNE

FAR AND NEAR

Solar Furnace at Broken Hill, Australia.

Solar Furnace to Aid Science

The advances in applied physics over the last decade have created urgent demands for metals and alloys that can function at temperatures inconceivable twenty years ago. Because conventional methods of testing these metals and alloys are unsatisfactory, Sydney scientists are planning to use concentrated heat from the sun.

The photograph above shows a model of the solar furnace already built and working at Broken Hill, western New South Wales. This model, which started to trap solar heat in November 1957, is 12 ft. high and supports a 3-ft. diameter paraboloidal mirror. It has developed temperatures of 3000°C, and has been an outstanding success in the examination of refractory materials.

Largest Solar Power Station Designed

Soviet scientists have designed the world's largest solar power-station for the Ararat Valley in Armenia, Dr Valentin Baum claimed at a solar engineering conference held recently in Kishinev, the capital of Moldavia.

Using mirrors with a total area of about 5 acres, he said, it was possible to generate 2,500,000 kWh of electricity and 20,000 tons of steam annually. He added that 1300 mirrors mounted on special carriages would move automatically along twenty-three concentric railways. It is planned to assemble the boiler on which the mirrors are to focus the sun's rays on a 130-ft. tower.

The Conference discussed scientific work on the use of the thermal energy of the sun and practical steps which are being taken in the Soviet Union. It was attended by specialists from Uzbekistan, the Ukraine, and the southern part of the Russian Federation.

It was pointed out at the Conference that there are already more than 107,000 sq. ft. of flat solar heaters in action in the Soviet Union. Work is now under way in the Crimea on the country's biggest flat solar water-heater.

Moldavia is climatically well suited to the use of solar energy. The Moldavian scientists have calculated that the republic's territory is irradiated by solar rays with a total capacity of 20,000 million kW. Solar installations can operate there for 200 to 300 days in the year.

The Moldavian Government has decided to construct in the next three years 1300 solar installations for food and light industry undertakings.

"Rain Dispersing" in Norway

Rain-making experiments are in the news these days, with the application of science to the problems of developing arid lands. But in Norway the problem is exactly the reverse: frequent heavy rains in the coastal areas do damage to crops and scientists have been trying to find a means of reducing rainfall in these regions.

Recent experiments consisting of spraying the clouds with silver iodide have proved successful in preventing the humidity from condensing into raindrops long enough for the winds to blow the clouds elsewhere.

According to Prof. Einar Höiland, of Oslo University, who is conducting these trials, the method should have the added advantage that clouds dispersed in this way would finally gather and shed their rain over the mountainous regions inland. This in turn would supply more water to the hydroelectric stations, and produce more power for the country's economy.

Underwater Search for Ancient Harbour

Divers and archaeologists from Israel and the United States will start underwater archaeological excavations in the Mediterranean this spring in an attempt to discover the ancient harbour of Caesarea. A preliminary survey made last year showed the outlines of the old harbour, which

appeared to be about four or five times larger than the present one.

Caesarea, the city from which Paul of Tarsus sailed in chains to Rome, is mentioned in the books of Josephus Flavius, who, in his history of the Jewish war against the Romans, referred to a temple and three "Colossei" built on the harbour's breakwater, all supported by huge cubic cut stones.

For many years fishermen off Caesarea have been catching in their nets jugs, vases, lamps, and other objects dating back to 1500 B.C. During last year's expedition, stones corresponding in size to those described by Flavius were found, as well as a Roman sarcophagus. The finds are considered promising and the Israeli Government is attaching one of its leading young archaeologists to the Caesarea expedition. The Smithsonian Institution of Washington, D.C., is expected to loan a team of experts.

First Geological Map of Asia

Geologists from fifteen Asian countries met in Calcutta recently to put the final touches to the draft of the first geological map of Asia, which is to be published this year. The map is of considerable importance, as a detailed and accurate knowledge of geological structure is a prerequisite for Asian countries in the exploitation of their mineral resources to create new industries.

Dr V. P. Sondhi, director of the Geological Survey of India and co-ordinator for the project, described how maps received from different countries had been fitted into the regional mosaic. Surveys of certain border areas, undertaken jointly by Malaya and Thailand, were described at the meeting, and the chairman, Dr Sultan Ahmed Popal, of Afghanistan, expressed the hope that countries with common frontiers such as Afghanistan, Pakistan, and India would carry out similar joint border surveys.

Dr Kinji Kanehara of Japan told the meeting of his country's pioneering in the use of aerial photography to study its volcanoes, and for oil exploration in shallow Japanese seas.

Delegates took back copies of the draft map to their countries for further study. These were to be returned to Dr Sondhi by February, and the map will be published towards the end of the year. Cost of the map—about £17,000—is being borne by the participating countries.

Increasing Death-rate for Aged Pedestrians

An increase of 100% or more in the mortality from traffic accidents among pedestrians over 65 years of age occurred in some countries between 1950 and 1955, while the death-rate for young pedestrians rose much less in some countries and decreased in others, according to a recently published study of the World Health Organisation (WHO), covering eighteen countries in all continents.

The greatest increase in the death-rate of pedestrians over 65 years of age has taken place in the Netherlands, where it rose from 40·5 annually per million inhabitants for the period 1950–2 to 96·8 for 1953–5, an increase of 139%, while the increase for all ages was 69·6. Next comes Norway, with a 104·3% increase (3·8 for all ages); Japan, with a 98·4% increase (37·7 for all ages); the Union of South Africa, with a 97·7% increase (67·8 for all ages); and Denmark, with a 60·4% increase (28·3 for all ages). The increase in the United Kingdom was from 154·1 pedestrians over 65 killed per million inhabitants in 1950–2 to 178·9 in 1953–5; that is, 16·1% up for people over 65 years of age, while the increase for all ages was 3% only.

The only countries where a decline in mortality has taken place are the United States of America (a 12·8% drop for pedestrians over 65 years of age, 13·4% for all age-groups) and Ireland (7·3% and 5·9% respectively).

The Lunar Society Meets Again

This famous society which was one of the first in the 18th century to concern itself with science, will be the subject of a residential summer course organised by the University of Nottingham to be held at Soho House, Soho Avenue, Birmingham, August 23–31, 1958.

The Lunar Society was one of the chief centres of progressive thought in the later 18th century, both in the sciences and outside them. Its members included Matthew Boulton, pioneer of modern industry and patron of science; his partner, James Watt, of steam-engine fame, who also shared in one of the key discoveries of modern chemistry; Joseph Priestley, as famous (or notorious) in his own time for his radical theology and politics as for his researches in chemistry and electricity; Erasmus Darwin, poet, political radical, and the first man to propose a well-rounded theory of organic evolution; William Withering, who proved the medical value of foxglove; Thomas Day, eccentric social reformer, philanthropist, author of one of the best loved children's books of all time, "Sandford and Merton"; his almost equally eccentric friend Richard Lovell Edgeworth, propounder of strikingly modern educational views; John Whitehurst, clock-maker and geological pioneer, and several others.

The course will be held in Soho House, Soho Avenue, Birmingham, which was Boulton's own house and the scene of many Lunar Society meetings, and is now owned by The General Electric Company (by whose kind permission it is possible to meet there). It now offers us not only historical associations but also comfortable accommodation in single rooms. The Lunar Society got its name from its custom of meeting at full moon to ease the difficulties of going home, and the opportunity will be taken of suitably celebrating the full moon of August 29.

There will be several visiting lecturers, experts in particular subjects, and it is hoped that these will include Mr W. K. V. Gale (on Watt's engines and other engineering developments) and Mr Eric Robinson (on Matthew Boulton). A good library of contemporary material will be assembled for those students who wish to undertake original inquiries, and excursions will be made to study at first hand the work of the "Lunatics" and their associates.

Electronic Computing System for Shell

A high-speed electronic computing system has been ordered by Shell to solve complex mathematical problems which arise in the planning of economic activity. It will be installed in the London Office and used for special calculations covering commercial aspects of all activities from exploration to marketing.

Based on the Ferranti "Mercury" machine with additional punched card, magnetic tape, and high-speed printing units, the computing system will be one of the largest in the world to be used mainly for operational analysis. It will also be one of the fastest systems in Europe for electronic processing of data.

The equipment will be able to store the equivalent of more than 60,000,000 decimal digits at a time, and the computer itself will perform up to 16,000 individual operations per second.

The present order has been largely influenced by Shell's successful experimental work over the last three years on the Ferranti electronic computer in their Amsterdam laboratory. This has demonstrated that computers allied with new mathematical techniques can make a real contribution towards the analysis of intricate business problems, thus assisting management in deciding on the best course of action in complex situations.

The new computing system is expected to be in full operation early in 1959.

Frogman Discovers Viking Ship

While exploring the wreck of a Viking ship beneath the waters of Roskilde Fjord off Frederikssund, in Denmark, a staff member of the Danish National Museum in Copenhagen trained as a frogman discovered another wrecked Viking vessel in a much better state of preservation. The museum hopes to use frogmen for exploring other wrecks in Danish waters.

Site for New U.S. Observatory Chosen

Kitt Peak, in the Quinlan Mountains, forty miles south-west of Tucson, Arizona, was approved by the National Science Foundation as the site for the new National Astronomical Observatory. The site was recommended to the Foundation by its contractor, the Association of Universities for Research in Astronomy, Inc. AURA, Inc., is responsible for the construction and operation of the new observatory under a contract with the National Science Foundation. The site was selected after a three-year study by a team of astronomers. Starting initially with some 150 sites in South-western United States, the choice was gradually narrowed to five sites, of which extensive tests were made.

The Kitt Peak site is at an elevation of 6875 ft. and has a flat area of 70 acres on the summit, usable for an observatory and auxiliary buildings. Observations were started on the site in January 1957. Equipment used to test the site include a 16-in. equatorial telescope.

The District and Tribal Councils of the Papago Indians, on whose reservation the mountain is located, have indicated their willingness to have the site used for scientific purposes. Kitt Peak is sacred to the Papagos, but in the interest of science they consented to having it tested for "seeing" and have been co-operating with the scientists working at the site.

Sir James Swinburne—100th Birthday

On February 28, 1958, Sir James Swinburne, F.R.S., celebrated his hundredth birthday. Sir James, who until 1953 was Chairman of Bakelite Limited, and who is now Honorary President of the Company, is a distinguished engineer and one of the world's pioneers in the field of synthetic resins. His original work on phenolic resins at the beginning of the century made a major contribution to the development of the modern plastics industry. Indeed, it can be justly said that he was the founder of the modern British plastics industry as it is known today.

Sir James Swinburne has always been interested in sociology, and among his publications is the work, "Population and the Social Problem". He has also been keenly devoted to music, and one of his early interests was the electric organ. Another of his hobbies is horology, and he has published books and papers on this subject. Sir James has now retired from active occupations to Bournemouth, where he enjoys his well-earned rest and leisure.

Marine Biology Institute Expanded

Bergen University's 65-year-old Marine Biology Institute, extensively expanded and modernised, has been re-dedicated. The project has so far cost well over £150,000. The Marine Biology Institute will work in close co-operation with other Scandinavian institutes in the same field. Scientific courses and the programme for exchanging scholars are now being mapped out by a Nordic Committee of Marine Biologists. The Norwegian Institute will be open to research workers from non-Scandinavian countries as well. The Norwegian Government has to date contributed about £125,000 to cover the construction cost. Another £3750 for scientific equipment has come from the Norwegian Council for Scientific and Industrial Research. In addition the new ocean research vessel *Fridtjof Nansen* has been assigned to the Bergen Institute.

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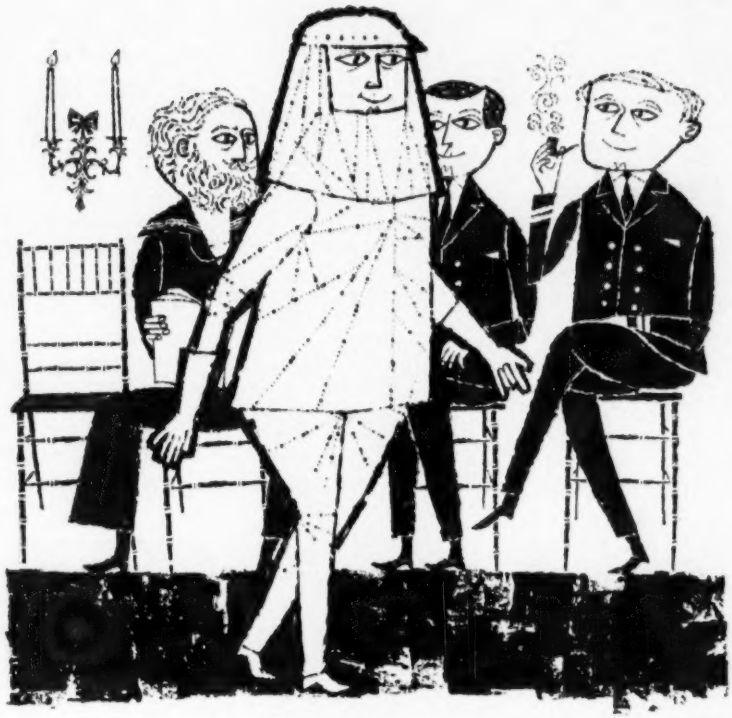

Submarine Fashions

H.M.S. Excalibur, a new type of submarine, is to be used in the training of anti-submarine surface forces. For Excalibur is capable of unusually high speed under water, thanks to her new fuel, High Test Peroxide. She will thus be able to tax to the full the resources of the pursuing frigates. But her new fuel brings its own special problems. Though High Test Peroxide is not itself inflammable, it generates such heat, when in contact with materials like wood or natural fibres, that spontaneous combustion can be caused. This hazard gave rise to particular difficulties in developing the use of High Test Peroxide in submarines. Clothing for the crew, as well as hoses and other equipment, had to be made from a material which, in contact with the fuel, would present no risk of fire. Because of its outstanding chemical resistance, 'Terylene' proved to be the *only* suitable textile material. It is used for the crew's clothing and, with p.v.c. coating for their protective overalls and hoods as well. Hoses and gaskets used in the handling of the new fuel are also made of p.v.c.-coated 'Terylene'. This is an example of the unusual and difficult handling problems that are being solved by the unique properties of this British fibre.

Thus, and in a thousand kindred ways, I.C.I.'s research and production are serving the Nation.

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